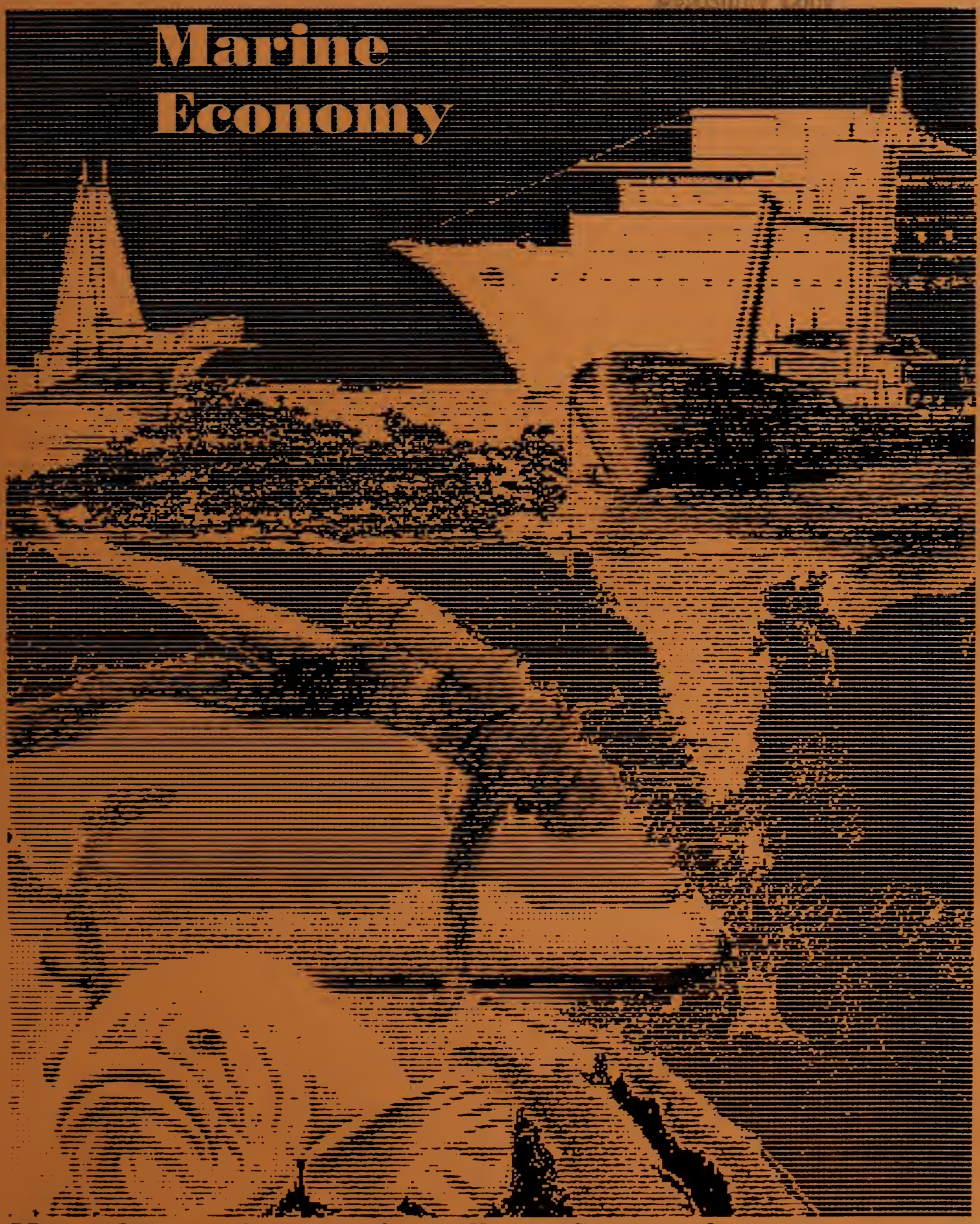
The Massachusetts Marine Economy



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The Massachusetts Marine Economy

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Diane Azevedo-Carns of Academic Computing Services at Southeastern Massachusetts University designed the publication. Sharon Georgianna drew the cover illustration.

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1 The Marine Economy of Massachusetts

"after long beatings at sea they fell with that land that is called Cape Cod; the which being made and certainly known to be it, they were not a little joyful... A word or two by the way of this cape. It was thus first named by Captain Gosnold and his company, Anno 1602, because they took much of that fish there."

William Bradford,
Of Plymouth Plantation

In 1602 Bartholomew Gosnold visited and named the land we now call Cape Cod. Even before this time, British, French, and Portuguese fishermen had used the shores of the new world to dry, salt, and prepare cod and other fish prior to shipment back to Europe. The famous landings of the *Mayflower* in 1620 and the *Arbella* in 1630 marked the beginnings of permanent settlement by Europeans of Massachusetts. Since these beginnings, the economy, culture, and society of Massachusetts have revolved around marine activities.

Until recently, marine activities in Massachusetts involved mainly fisheries and the building of ships and boats. While these continue as an important part of the Massachusetts marine economy, electronics, recreation, and environmental research have become significant new components. In addition, marine industries are connected to many other sectors of the economy as buyers of their products or as sellers of required materials.

The marine economy is a major source of jobs, income, and prosperity in Massachusetts. Many industries statewide are involved and connected in ways that sometimes are not obvious. Marine interests in Massachusetts have much in common whether they are located near coastal areas or inland.

Identifying the Marine Economy

Although many marine activities are located in coastal communities, the marine economy of Massachusetts extends beyond coastal areas. The scope of this study is, therefore, partly geographical and partly industrial. We will focus both on commercial fishing and marine recreation concentrated in coastal cities and towns and on industrial categories, such as marine electronics, that are located throughout the state. Coastal areas and industrial categories are defined in Appendix A.

Our goals are to estimate employment and payroll in the various sectors of the marine economy, to summarize the totals for the entire marine economy of Massachusetts, and to identify important characteristics and trends within each marine industry. We have taken a conservative approach to identifying the scope of the marine economy. Some of the data we wanted were not available. Other data on marine activities were inextricably combined with non-marine data. When it has been impossible to separate marine from non-marine data, we have tended to leave out categories entirely rather than include information that contained significant non-marine components. We would argue, therefore, that the estimates of the marine economy provided in this study are a lower bound on its true size and scope.

In the course of the study, we have identified a number of interesting and important characteristics, changes, and trends in the marine economy that would merit additional, more detailed study. These are noted as they occur in the following sections

Table 1. Population Growth, 1980 to 1990

	1980	1990	Absolute Change	Percent Change
Barnstable County	147,925	186,605	38,680	26.15%
Dukes County	8,942	11,639	2,697	30.16%
Nantucket County	5,087	6,012	925	18.18%
Cape Cod & Islands	161,954	204,256	42,302	26.12%
Coastal Towns &Cities Of:				
Bristol County	278,814	282,919	4,105	1.47%
Essex County	285,216	296,510	11,294	3.96%
Norfolk County	147,518	146,123	-1,395	-0.95%
Plymouth County	151,354	166,730	15,37	10.16%
Suffolk County	650,142	663,906	13,764	2.12%
Total Coastal Cities and Towns	1,666,056	1,748,805	82,749	4.97%
Total Non-Coastal Cities and Towns	4,071,037	4,267,620	196,583	4.83%
Total Massachusetts	5,737093	6,016,425	279,332	4.87%

Source: Mass. State Data Center, returns of U.S. censuses of 1980 and 1990, by counties, cities, and towns in Massachusetts

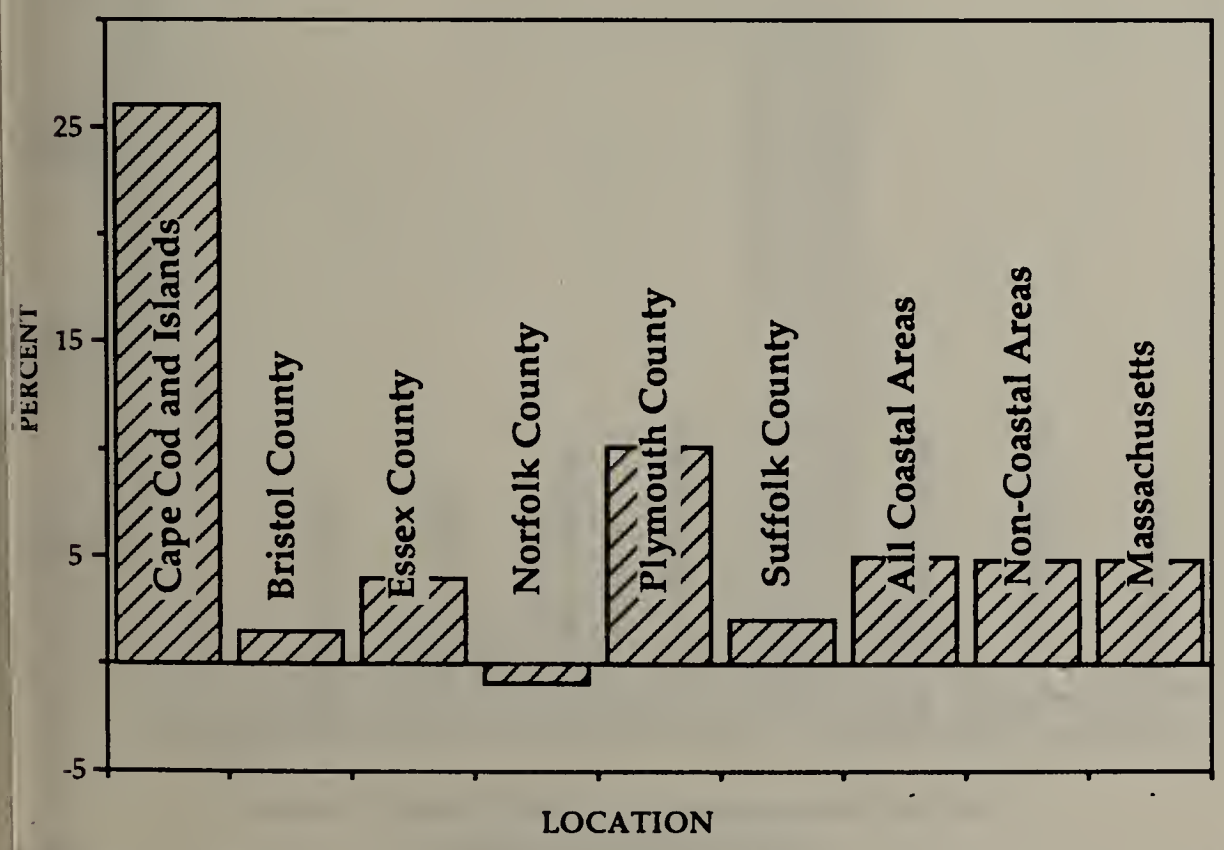


Figure 1. Population Growth, Percent, 1980-1990 (U. S. Bureau of the Census)

Population Growth and Real Estate Values

During the decade 1980 to 1990, Cape Cod and the Islands and the coastal areas of Plymouth county grew much faster than other coastal areas and faster than Massachusetts as a whole. Cape Cod and the Islands grew by 26 percent, the coastal areas of Plymouth county grew by 10 per cent, while other coastal areas and the state as a whole grew by 5 per cent (Figure 1). The official counts of the United States censuses of 1980 and 1990 are shown for various areas in Table 1. The coastal areas of Bristol, Essex, Norfolk, and Plymouth counties do not include the entire counties. Coastal areas in Barnstable, Dukes, Nantucket (Cape Cod & Islands), and Suffolk counties include the entire counties.

The growth of real estate values during the past decade is one of the most widely known economic facts in Massachusetts. The value of coastal real estate has traditionally been higher than the state average. Currently, coastal real estate per acre is worth approximately two and one-half times non-coastal real estate. While this differential has been maintained over the past decade, both coastal and non-coastal real estate values have increased substantially. Values, measured in terms of "equalized valuation" as calculated by the Massachusetts Department of Revenue, increased by approximately 85 percent from fiscal year 1984 to fiscal year 1990 (Figure 2).

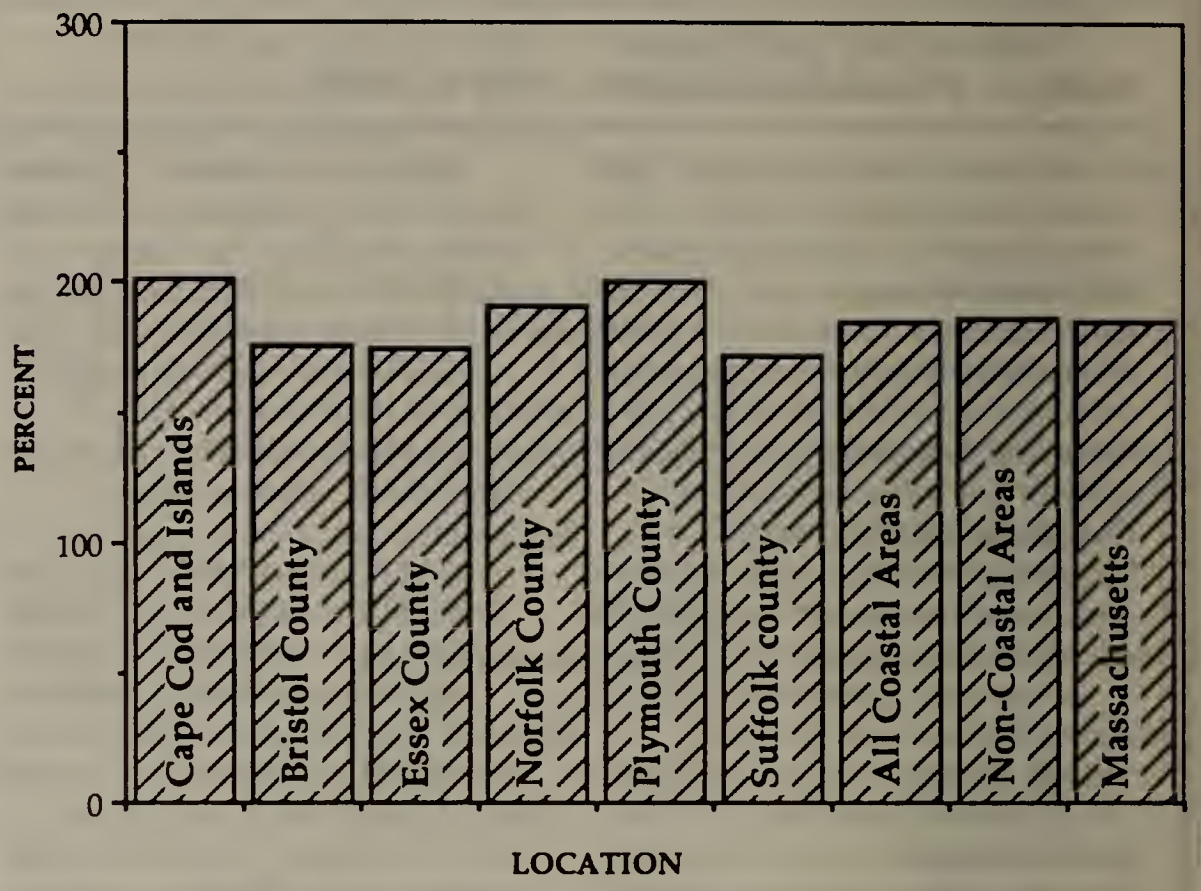


Figure 2. 1990 Real Estate Values As Percent of 1984 (Mass. Dept. of Revenue)

Table 2. Equalized Valuation per Square Mile, 1990 (dollars per square mile)

Barnstable County	$77,749,697
Dukes County	41,244,620
Nantucket County	78,416,551
Total Cape Cod & Islands	70,835,693
Coastal Cities and Towns Of:	
Bristol County	62,186,442
Essex County	110,396,203
Norfolk County	221,874,312
Plymouth County	56,701,040
Suffolk County	748,839,714
Total Coastal Cities and Towns	106,411,077
Non-Coastal Cities and Towns	44,120,103
Total Massachusetts	54,647,708

Source: Land Areas from U.S. Census of 1980, as provided by the Massachusetts State Data Center; Equalized Valuations for fiscal year 1990 provided by Mass. Dept. of Revenue, Division of Local Services, Data Bank

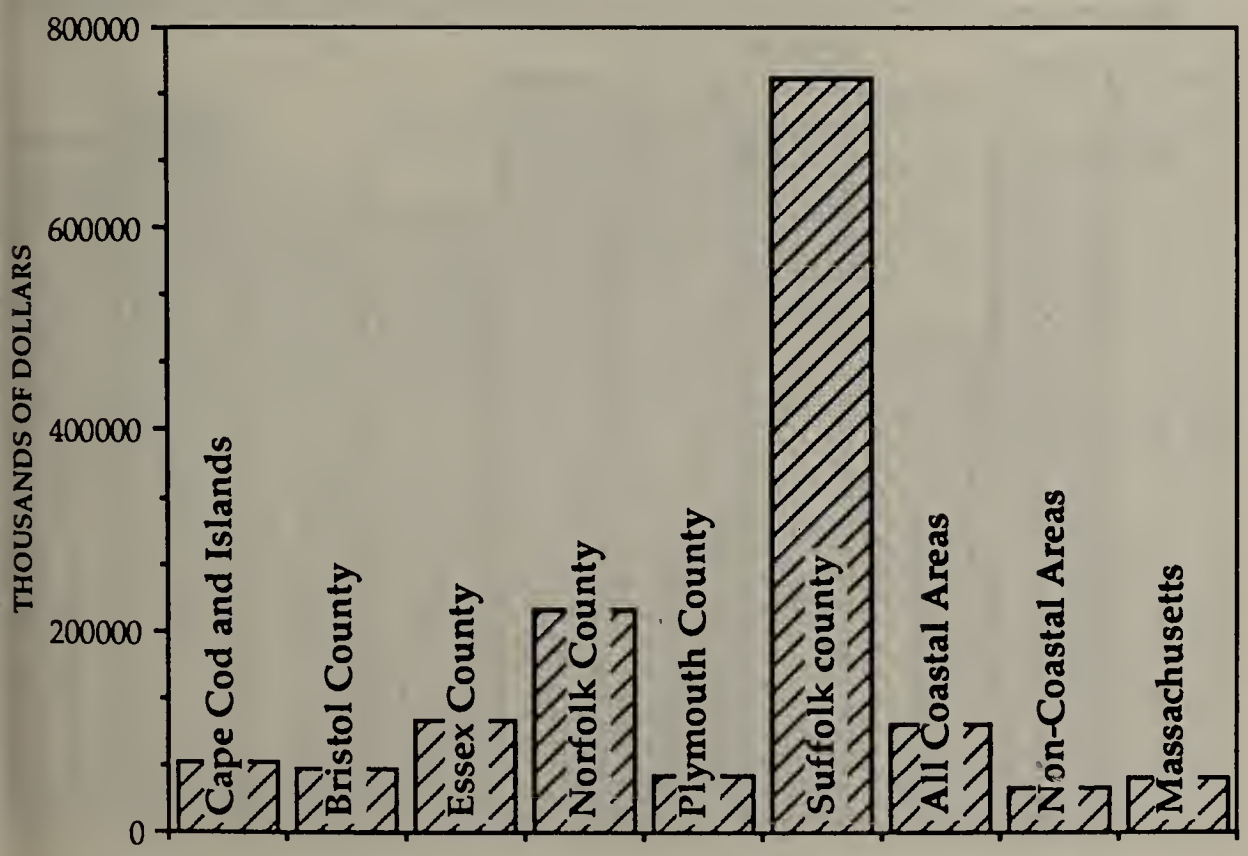


Figure 3. Real Estate Value per square mile, 1990 (Mass. Dept. of Revenue)

Table 2 and Figure 3 show real estate values per square mile for coastal and non-coastal communities for fiscal year 1990.

Real estate sales generate employment and income directly through sales commissions, financial services, surveys, appraisals, advertising, and other activities. Higher real estate values would generate greater employment and income for these activities. New construction generates higher real estate tax revenues for cities and towns.

Marine-related real estate employment, payroll, and incomes cannot be separately identified in the available data sources. However, the direct income effects of increased real estate values may be roughly estimated. The total increased valuation in coastal communities from 1984 to 1990 was $91,279,704,000. If total associated sales commissions, financial services, surveys, and other service fees average 7 percent of selling prices, and if 10 percent of real property changed hands during the period 1984 - 1990, $639 million of income would be generated by this increased valuation. Such an estimate of direct service income is in addition to the capital gains income to property owners. These estimates are not comparable with the data on employment and payroll for other marine industries, and are not included in the totals given below in Table 6.

Per capita incomes vary substantially among coastal communities. Table 3 presents the most recent estimates by the United States Bureau of the Census of per capita incomes expressed as a percentage of the statewide average per capita income (a value of 100 in this table means that the area had a per capita income equal to the state average). Figure 4 shows the data in graphic form.

Unfortunately, actual per capita incomes (as opposed to estimates by the Bureau of the Census) for cities and towns from the 1990 census are not yet available. The table indicates that areas in both the North Shore and South Shore are considerably above the state average. Bristol county and Suffolk county are both below the state average.

Table 3. Estimated Per Capita Income As a Percent of Massachusetts Per Capita Income, 1987

Barnstable County	98.0%
Dukes County	95.1%
Nantucket County	141.8%
Total Cape Cod & Islands	99.1%
Coastal Communities Of:	
Bristol County	71.1%
Essex County	102.5%
Norfolk County	105.4%
Plymouth County	108.9%
Suffolk County	89.5%
Total Coastal Communities	92.9%
Non-Coastal Communities	102.9%
Total Massachusetts	100.0%

Source: U.S. Bureau of the Census, as provided by Mass. State Data Center

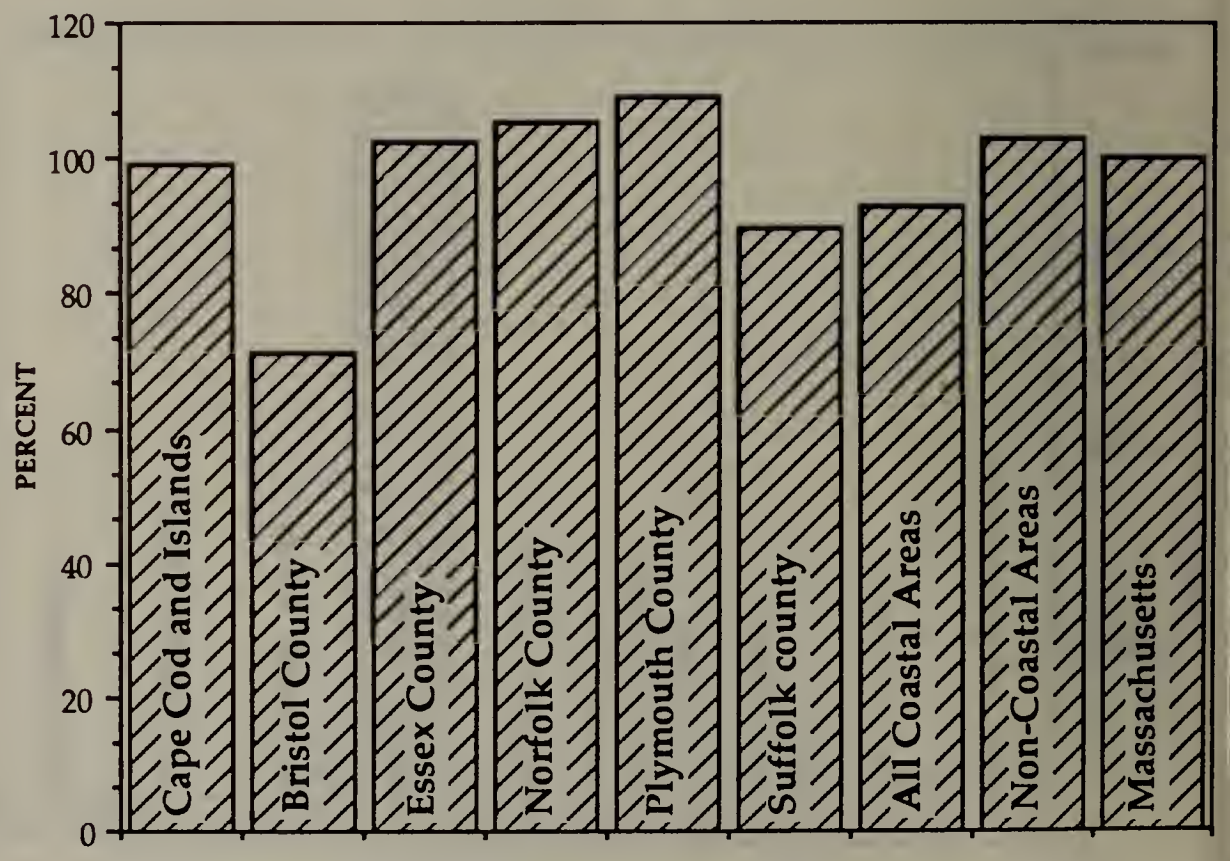


Figure 4. Per Capita Income as Percent of Massachusetts, 1987 (U. S. Bureau of the Census)

Table 4. Estimated Percentage Increase in Per Capita Income, 1979 to 1987 (Growth Rate in Percentage Terms)

Barnstable County	89.9%
Dukes County	86.9%
Nantucket County	104.3%
Total Cape Cod & Islands	90.2%
Coastal Communities Of:	
Bristol County	76.4%
Essex County	88.5%
Norfolk County	92.4%
Plymouth County	99.9%
Suffolk County	96.4%
Total Coastal Communities	91.1%
Non-Coastal Communities	93.8%
Total Massachusetts	93.0%

Source: Mass. State Data Center from U.S. Census of 1980 and Census estimates

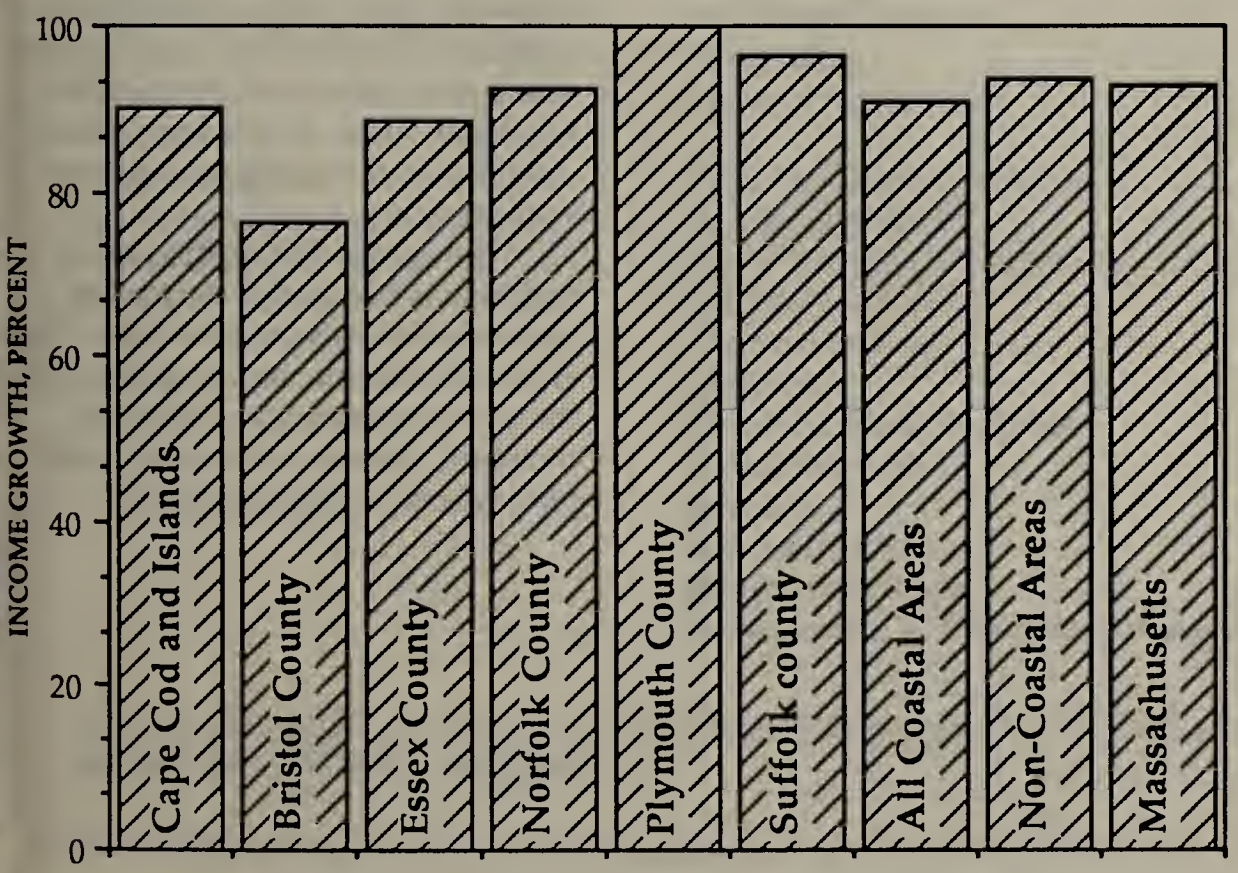


Figure 5. Growth of Per Capita Income, Percent, 1979-1987 (U. S. Bureau of the Census)

Income growth has also varied considerably among coastal cities and towns in Massachusetts. Table 4 and Figure 5 show U.S. Census estimates of per capita income growth from the actual values for 1979 (from the 1980 census) to the 1987 estimates.

Though the coastal communities taken together grew less rapidly than the non-coastal cities and towns in the state, Nantucket, the coastal part of Plymouth county, and Suffolk county grew more rapidly than the state average.

The combined effect of Tables 1 - 4 is to raise some interesting questions. The populations of Cape Cod and the Islands and coastal Plymouth county grew substantially faster than the state as a whole. It may be surmised that this growth was due to migration into these areas rather than from an excess of births over deaths. This migration can be due, however, only in part to higher or more rapidly growing incomes. Coastal Plymouth county's per capita income is 108 percent of the state average, but that of Cape Cod and the Islands is only 99 percent of the state average. Also, while coastal Plymouth county's per capita income grew more rapidly than the rest of the state (99.9 percent vs. 93 percent), Cape Cod and the Islands grew less rapidly (90.2 percent). Population growth, presumably in the form of migration, has been influenced by factors other than income in the case of Cape Cod and the Islands. Future studies might usefully address this issue and attempt to specify the entire range of factors involved and their relative importance. Such studies will necessarily await the release of the more detailed information of the 1990 Census of the United States.

Marine Industries

The industries that make up the marine economy and are the focus of this study include the following:

Commercial Fishing
Fish Processing, Wholesaling, and Retailing
Fishing Materials and Supplies
Marine Recreation Activities, including Recreational Fishing
Marine Aquaculture
Marine Electronics and Instruments, including Defense Contracting
Marine and Coastal Environmental Services
Marine Research and Education
Ship and Boat Building and Repair, and Retail Boat Sales
Water Transportation

Connections to Other Industries

Direct demand by marine industries from other industries is estimated from the most recent input-output table for the United States and current information on employment and payroll from the Massachusetts Department of Employment and Training. The following estimates show only the immediate purchases (direct effects) made by marine industries from their major supplying industries. The estimates exclude all purchases from relatively minor supplying industries.

The data of Table 5 suggest that there are strong economic connections among marine industries. For example, commercial fishing buys from ship and boat building and repair, and fish processing buys from commercial fishing. Also, marine industries are important customers of many other non-marine industries. Both commercial fishing and water transportation buy petroleum products; ship and boat building and repair firms buy glass, resins, lumber, and engines; and all marine industries buy substantial amounts of products in wholesale trade. In this way, marine activities have impacts on the entire state economy.

Throughout this study, our intention is to describe the marine economy and its various sectors. This is not an economic impact analysis of the marine economy and does not, therefore, identify indirect or multiplier effects of marine activities.

Table 5. Estimated Direct Purchases by Massachusetts Marine Industries from Other Selected Industries

Marine Industry	Bought From	1989 Amount
Commercial Fishing (Est. total output = $322,083,050)	Ice Manufacturers	$ 4,719,321
	Cordage & Twine	9,289,835
	Petroleum Refiners	22,767,536
	Ship & Boat Bldg & Repair	33,566,704
	Water Transport	2,487,210
	Wholesale Trade Supplies	9,948,839
Fish Processing (Est. Total Output = $483,648,522)	Commercial Fishing	170,115,041
	Building Maintenance & Repair	3,579,104
	Packaging Materials	18,482,262
	Motor Freight Transport	6,180,312
	Wholesale Trade Supplies	74,457,112
	Advertising	2,620,765
Ship & Boat Building & Repair (Est. Total Output = $68,174,195)	Wood & Lumber Products	1,813,620
	Plastics & Resins	2,281,579
	Paints, Varnishes, etc.	441,090
	Glass	1,408,354
	Steel, Alum. & Fabr. Metals	5,434,142
	Screws and Hardware	745,599
	Engines, Transmissions	7,997,840
	Motor Freight Transport	398,549
	Real Estate Services	911,288
	Advertising	282,119
	Engineering Services	315,704
Water Transport (Est. Total Output = $360,978,568)	Bldg. Maintenance & Repair	1,293,401
	Petroleum Refining	3,847,846
	Ship & Boat Bldg & Repair	1,989,564
	Freight Forwarders	930,528
	Communications	748,860
	Electricity	573,664
	Wholesale Trade Supplies	746,086
	Finance Services	1,133,922
	Insurance	1,247,638
	Real Estate Services	1,206,034
	Misc. Repair Shops	946,245
	Management & Consulting Service	935,150

Source: Calculated and Estimated from United States Input-Output Table and DET ES202 File payroll data. See Appendix A, Note 4 for details.

Summary of the Massachusetts Marine Economy

The following sections examine the marine industries in detail. The findings are summarized in this section. Employment and payroll in the Massachusetts marine economy are substantial. Table 6 shows employment and payroll for each of the major sectors of the marine economy. These data are illustrated in Figure 6 and Figure 7 which show the relative shares of the component industries in terms of employment and payroll respectively.

The marine economy of Massachusetts employed 81,826 people and generated nearly one and three-quarters billion dollars in payroll in 1989. These measures indicate the minimum size of the marine economy. In cases when it has not been possible to separate marine from non-marine activities, our approach has been to leave out a category rather than to include significant non-marine components. These estimates should therefore be interpreted as conservative estimates.

The most important trends and characteristics in the marine economy of Massachusetts are quite similar to those in the Massachusetts economy as a whole. They include:

1) There has been a steady loss of jobs in traditional manufacturing. This is exemplified in ship and boat building and repair, where the industry has suffered a major decline since the closing of the Quincy shipyard in 1985. New technologies such as composite materials may provide the basis for a comeback in these industries.

Table 6. Employment and Payroll by Industry, Massachusetts Marine Economy, 1989

Marine Industry	Employees	Payroll in $ thousands
Commercial Fishing	3692	118,000
Fish Processing	3605	62,000
Retail and Wholesale Fish Sales	2446	42,000
Seafood Restaurants	24,533	228,700
Marine Recreation and Tourism	22,300	319,000
Aquaculture	400	500
Electronics	17,131	632,660
Environment	502	65,000
Research/Education	1750	134,700
Boat Building & Sales	2485	61,316
Water Transportation	2982	74,579
TOTAL	81,826	1,738,455

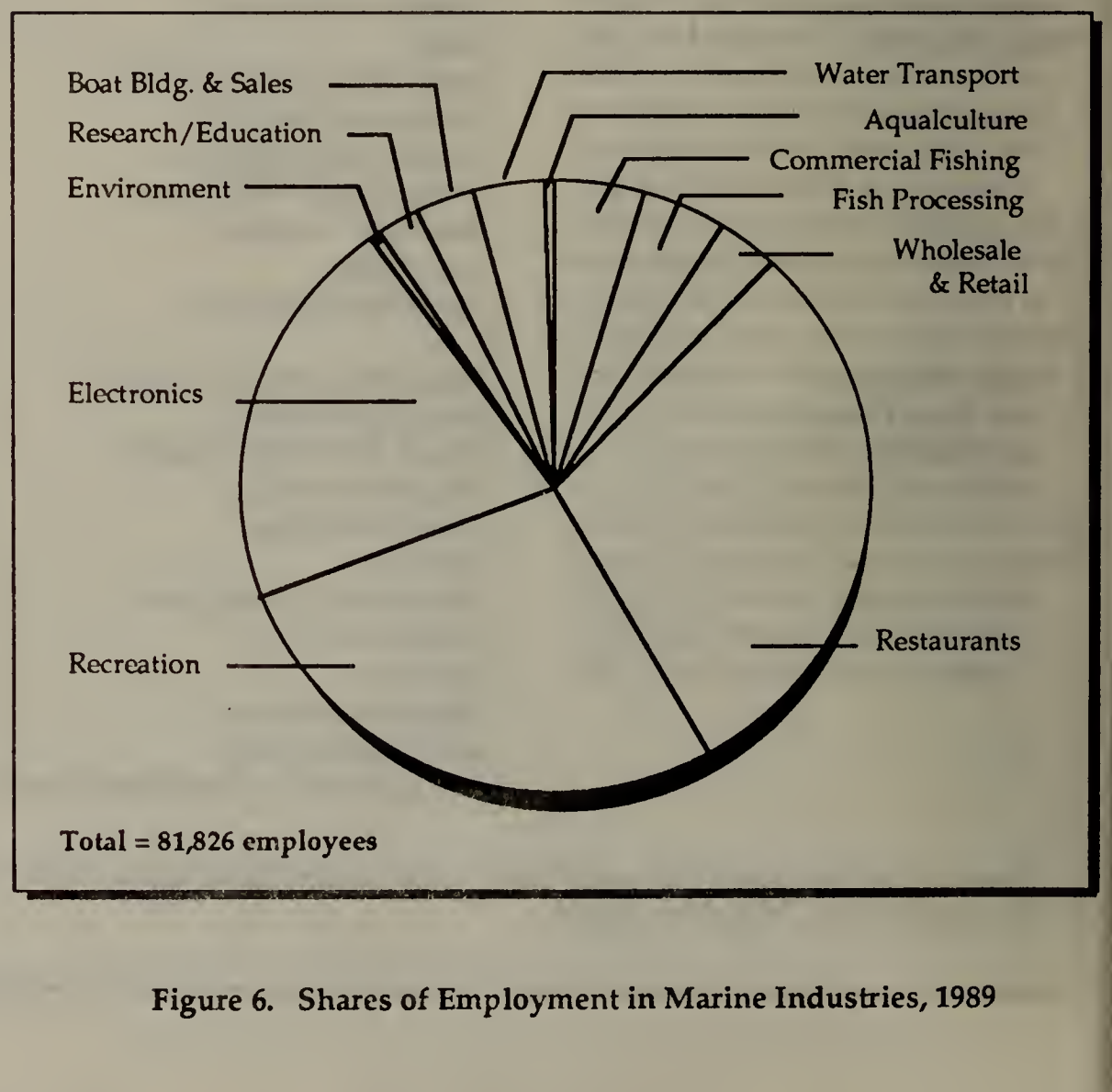


Figure 6. Shares of Employment in Marine Industries, 1989

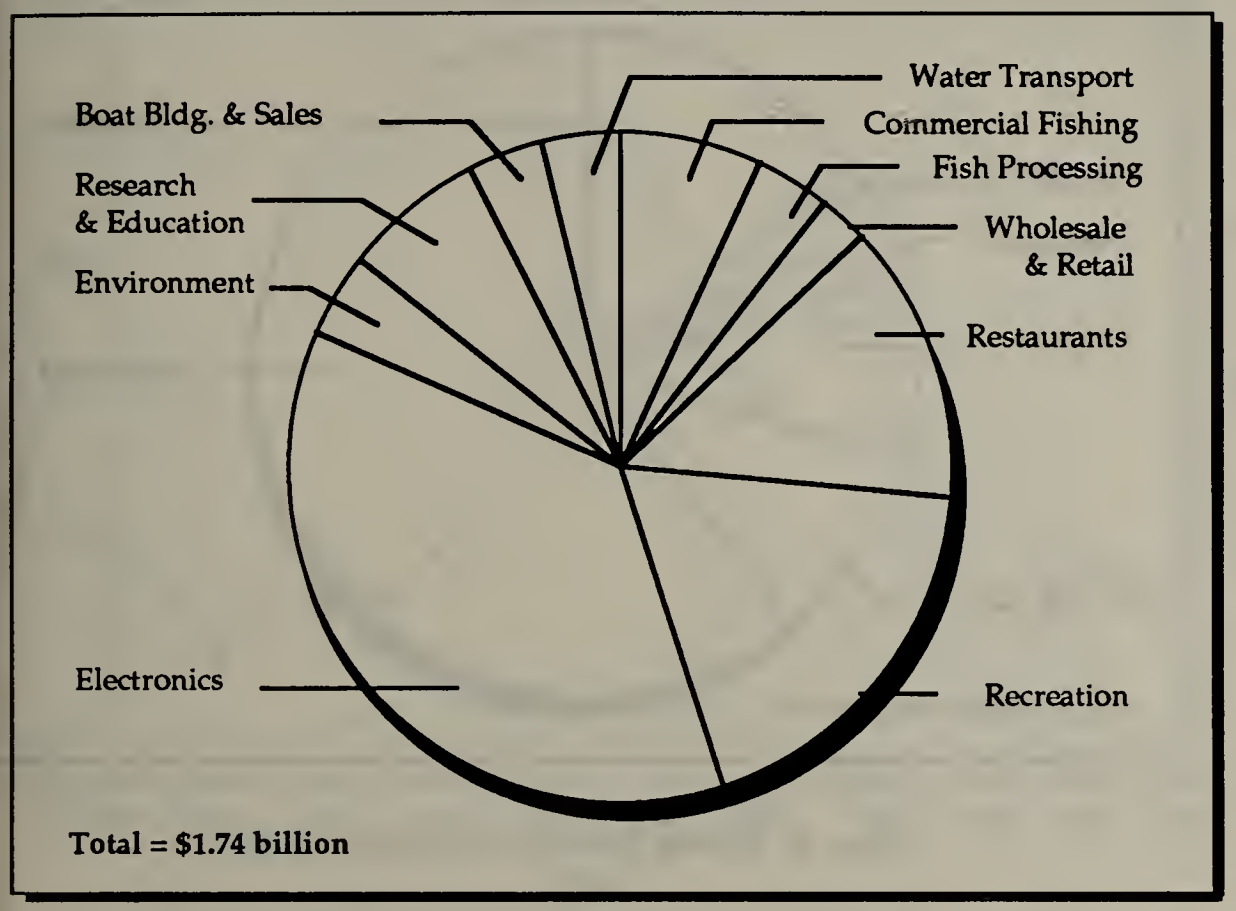


Figure 7. Shares of Payroll in Marine Industries, 1989

2) There has been a steady growth in electronics-based manufacturing that has more than offset the loss of traditional manufacturing jobs. Marine electronics has stabilized, however, in the face of competition from other domestic and foreign firms and the recession that began in the northeast earlier than in the rest of the country.

3) Science-based service industries have become a significant part of the marine economy. Employment has been relatively strong and stable in marine environmental activities and in marine research and education.

4) Though traditional service industries, such as seafood restaurants, retail boat sales, water transportation, and marine recreation, have suffered the ill effects of the present recession, employment has not declined as sharply as in traditional manufacturing. The collapse of the northeast real estate market and the difficulties of the banking industry are correlated with the trends in the marine economy, but extend beyond the marine economy to include the entire economic system.

5) Commercial fishing has experienced a substantial decline in landings due to a decline in accessible stocks of fish. More trips by more boats are resulting in fewer fish brought into port. Research continues on the question of whether this is due to a natural cycle among fish populations or to overfishing. Evidence to support the overfishing hypothesis is provided by the fact that the declines have occurred in almost all species.

6) Fresh fish processing has been adversely affected by the decline in domestic landings. Fish processors have attempted to substitute imports of whole fish from Canada to maintain a normal rate of operations.

7) The experiments in marine aquaculture generally have not been successful. Only in the case of mussels has there been an increase in production during the past decade. There appear to be biological, environmental, and economic problems facing marine aquaculture. An extension to finfish from the present emphasis on shellfish may rejuvenate this industry.

8) The present recession has had an adverse influence on the marine economy of Massachusetts. Massachusetts continues to have, however, strong economic advantages in science-based services, research, education, electronics-based manufacturing, commercial fishing, recreation, and tourism. Policies to encourage these sectors of the marine economy of Massachusetts will provide the basis of a strong economy in the twenty-first century.

2 The Massachusetts Fishing Industry

When you order fish in a local restaurant or buy fresh fish at your local fish market, you are buying a unique Massachusetts product. The fish was probably caught by Massachusetts fishermen, prepared and sold by Massachusetts processors, and served by Massachusetts restaurant workers. Most of the inputs used by these firms, such as fuel, ice, gear, and packaging, also probably came from Massachusetts suppliers. Frozen fish products, sold in supermarkets, restaurants, and fast food chains such as McDonald's and Burger King, are also prepared by Massachusetts processors from Canadian and other imports.

Recreational fishing is also important to the state's economy. Each year 700,000 Massachusetts residents and 400,000 out-of-state visitors fish in Massachusetts waters, use Massachusetts marinas and boat yards, buy bait, gear, and other supplies here, stay in local motels, and eat in local restaurants.

In 1989, commercial fishing, recreational fishing, marine supplies, processing, retail sales, restaurants, and the other sectors of the Massachusetts fishing industry employed 40,500 people and paid $511 million in wages and salaries (Figure 8). A principal industry throughout its history, the Massachusetts fishing industry remains important to the state's economy.

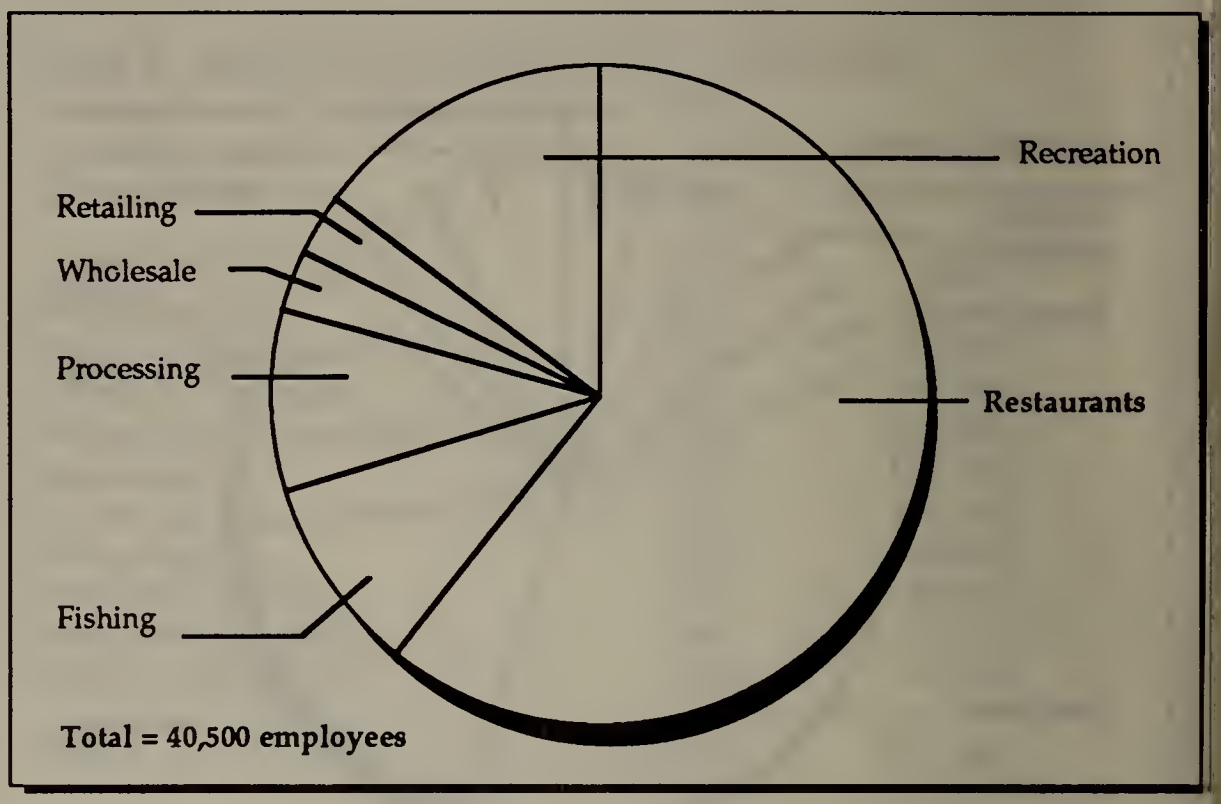


Figure 8. Fishing Industry Employment, 1989

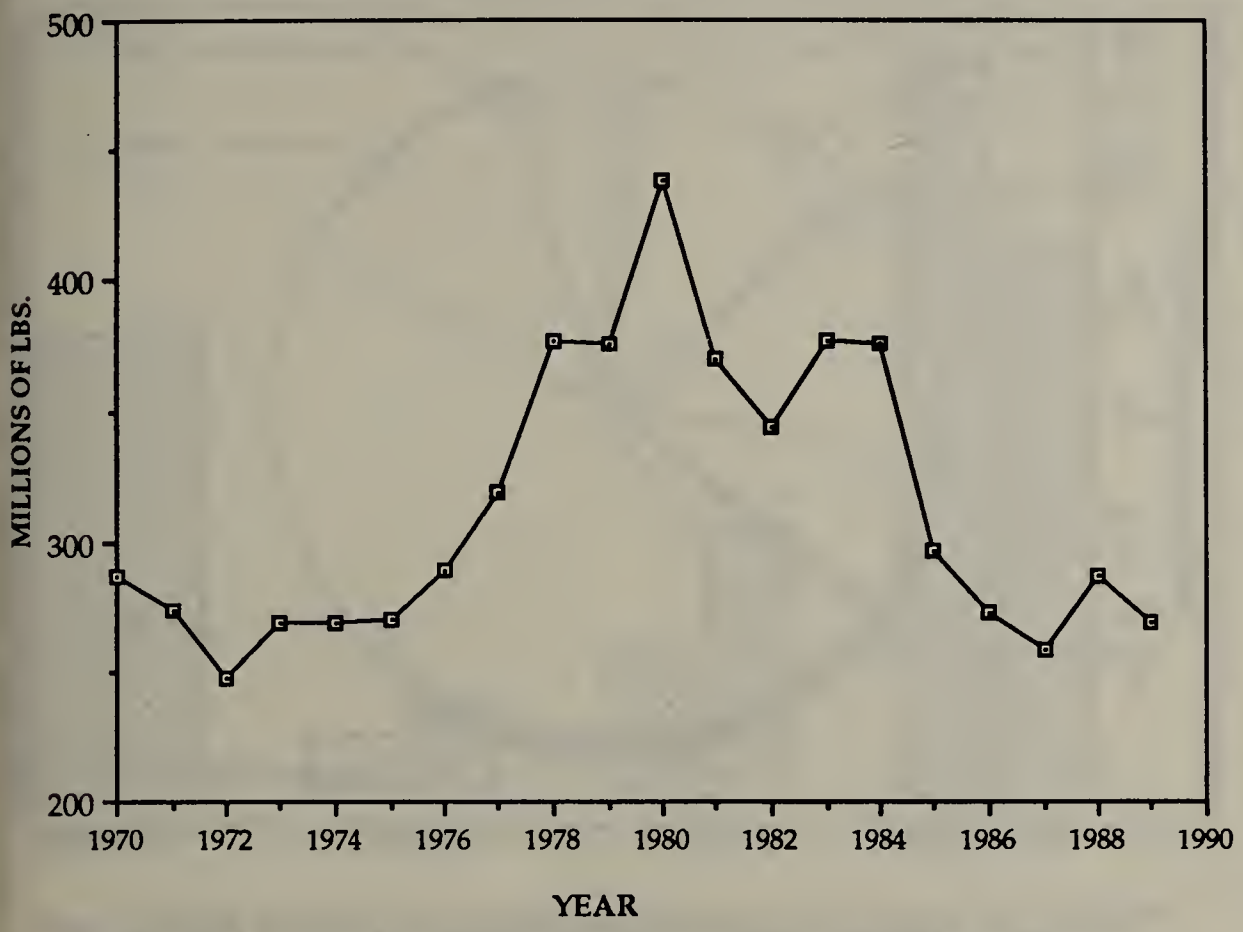


Figure 9. Commercial Marine Catch in MA (Fisheries of the U.S.)

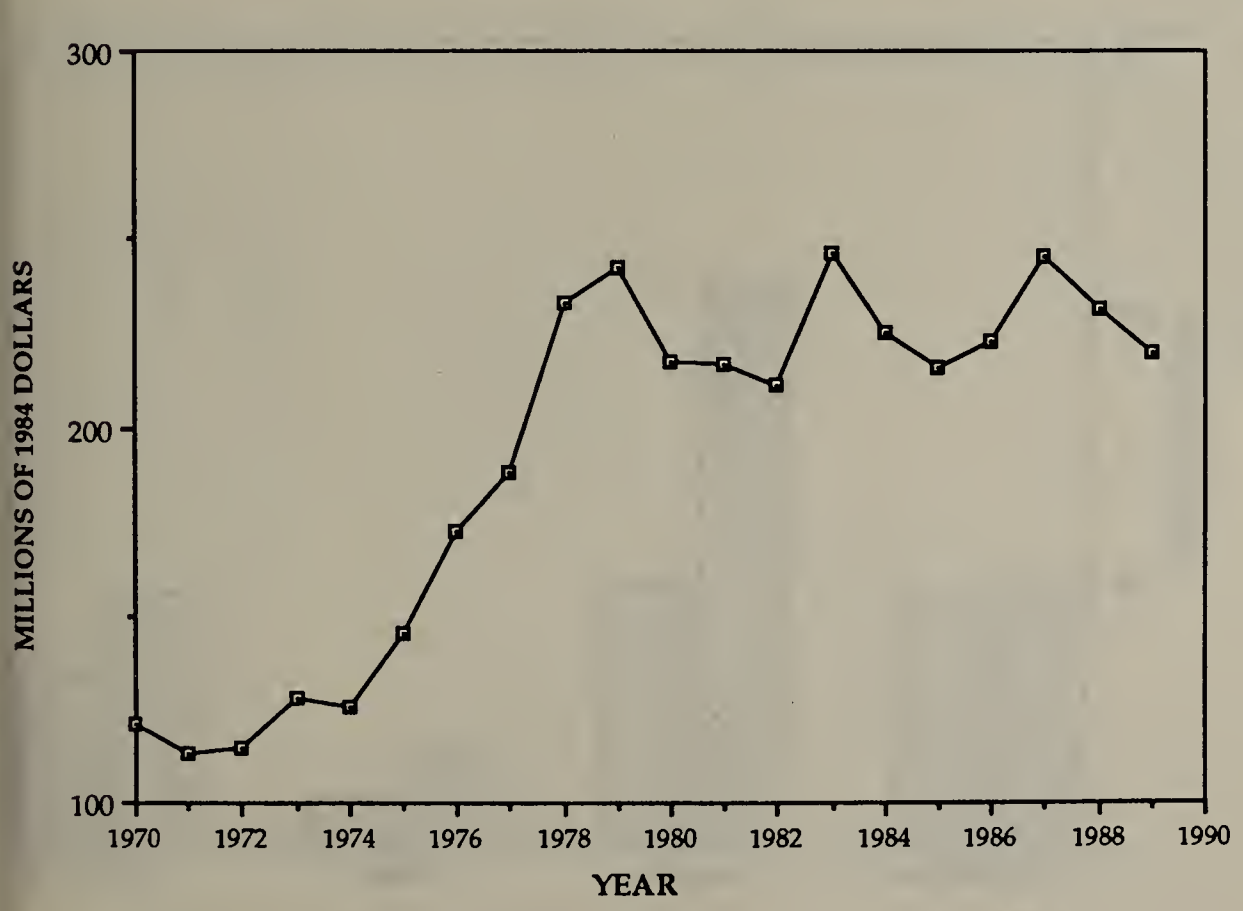


Figure 10. Value of Commercial Marine Catch in MA in 1984 Dollars (Fisheries of the U.S.)

Commercial Fishing

From before colonial times until the late 1800s, fishing led the Massachusetts economy. One of the richest fishing areas in the world, Georges Bank, is just off Cape Cod. Gloucester led the way with its large fleet of two-masted schooners, taking summer-long voyages to Georges and the Grand Banks. Fishing was also the mainstay of Cape Cod and other seaside ports. Around the turn of the century, Boston joined Gloucester as a major fishing port, and during the 1920s and 1930s, New Bedford seafarers turned to fishing as the whaling industry finally gave out. The state's largest catches were recorded just after World War II, with the record catch of 650 million pounds in 1948. But the industry suffered a sharp decline through the 1960s as foreign fleets harvested most available fish with their large fleets of modern factory trawlers.

Recovery came with the establishment of the 200-mile exclusive fishery zone in 1976. As shown in Figure 9, the total catch increased sharply as Massachusetts fishermen replaced foreigners on Georges Bank. However, after 1980 landings fell as the stocks of the most important species began to decline.

This loss in quantity was offset by the steady rise in fish prices, due to consumers' increasing interest in a healthy diet. Average price per pound at the dock about doubled in Massachusetts between 1980 and 1987, before dropping slightly in 1988. Since fish prices rose more than the average rate of inflation, the value of the catch after acccounting for inflation remains near its peak (Figure 10).

In 1989, Massachusetts's 4,000 full-time commercial fishermen and 7,000 part-time commercial fishermen landed 250 million pounds of fish with a current dock-side value of about $300 million. About two-thirds of full-time fishermen now work out of New Bedford, but fishing is also an important employer in Gloucester, Boston, and in many smaller ports on Cape Cod and elsewhere. Nine hundred commercial fishing boats and vessels are distributed along the coast, with about 300 in New Bedford, 250 in Gloucester, 250 on Cape Cod and the islands, 70 in Boston, and 50 in other ports throughout the state.

With a landed value of $140 million, mostly from scallops, New Bedford led the nation's ports in value in 1989, as it has for 6 of the last 7 years (Figure 11). Since 1980, the value of landings after accounting for inflation dropped in Gloucester and Boston and remained about the same on Cape Cod and in the other ports throughout the state.

Gloucester, long the leader in cod and haddock, landed the greatest weight of fish and shellfish in Massachusetts. But the the catch in Gloucester fell by more than one-half, from over 200 million pounds in 1980 to about 100 million pounds in 1989 (Figure 12). The total catch also fell in New Bedford, Boston, and the other ports, but by much less than the sharp decline in Gloucester.

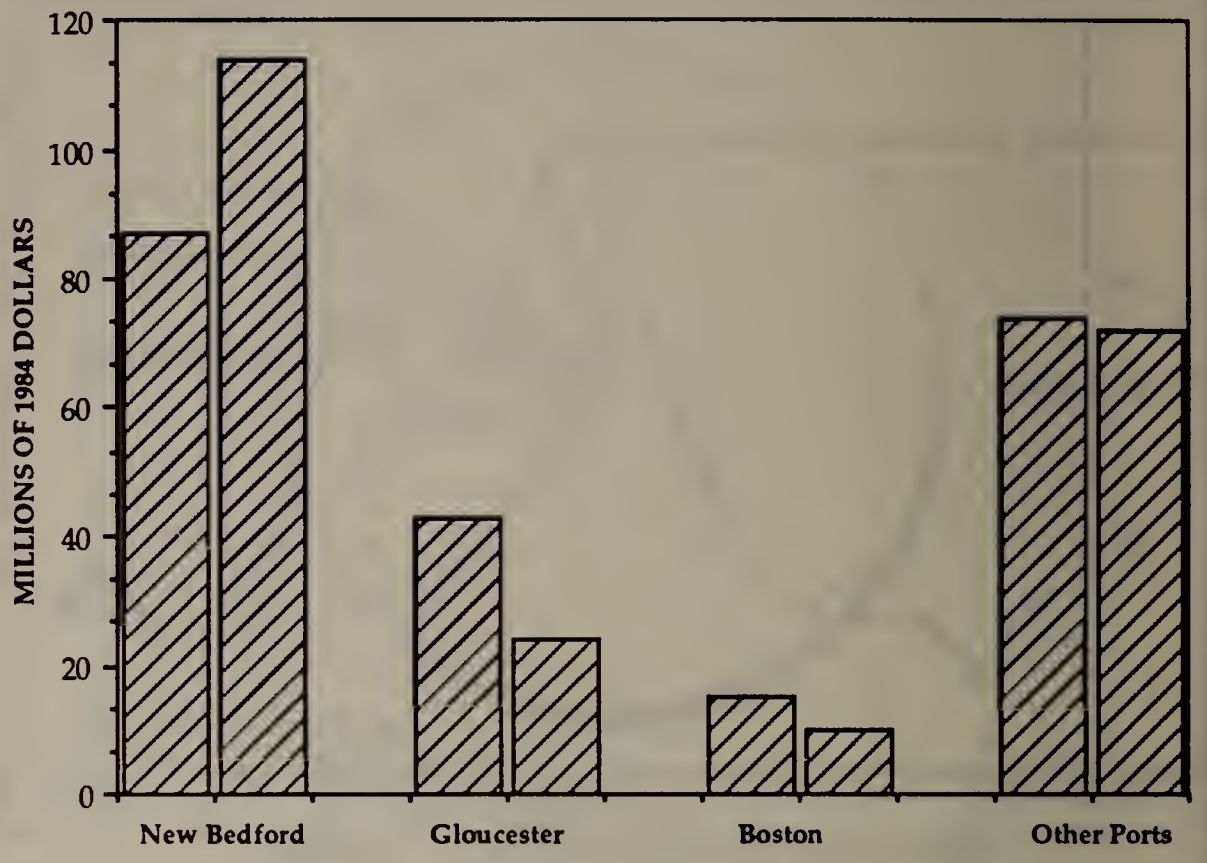


Figure 11. Value of Landings in 1984 Dollars by Port in 1980 and 1989 (Fisheries of the U.S.)

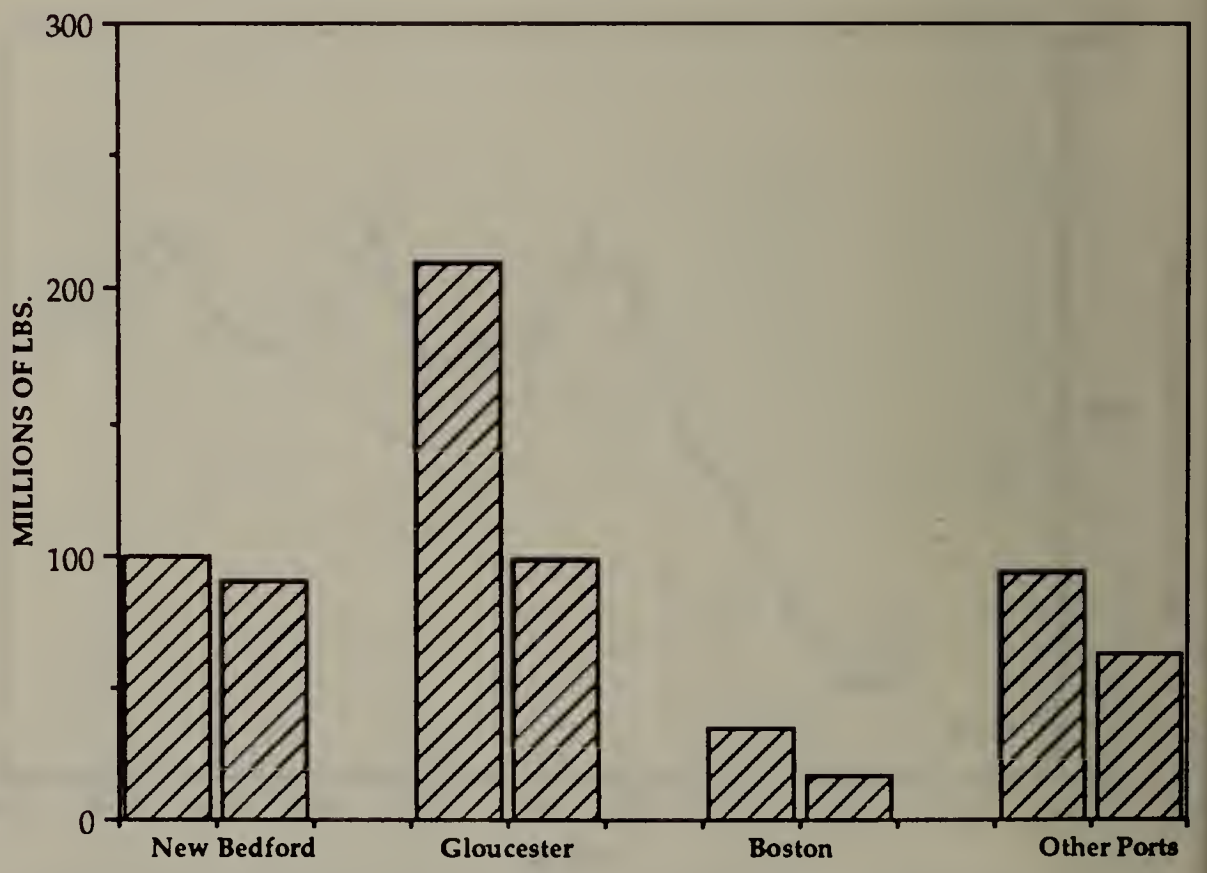


Figure 12. Commercial Catch by Port for 1980 and 1989 (Fisheries of the U.S.)

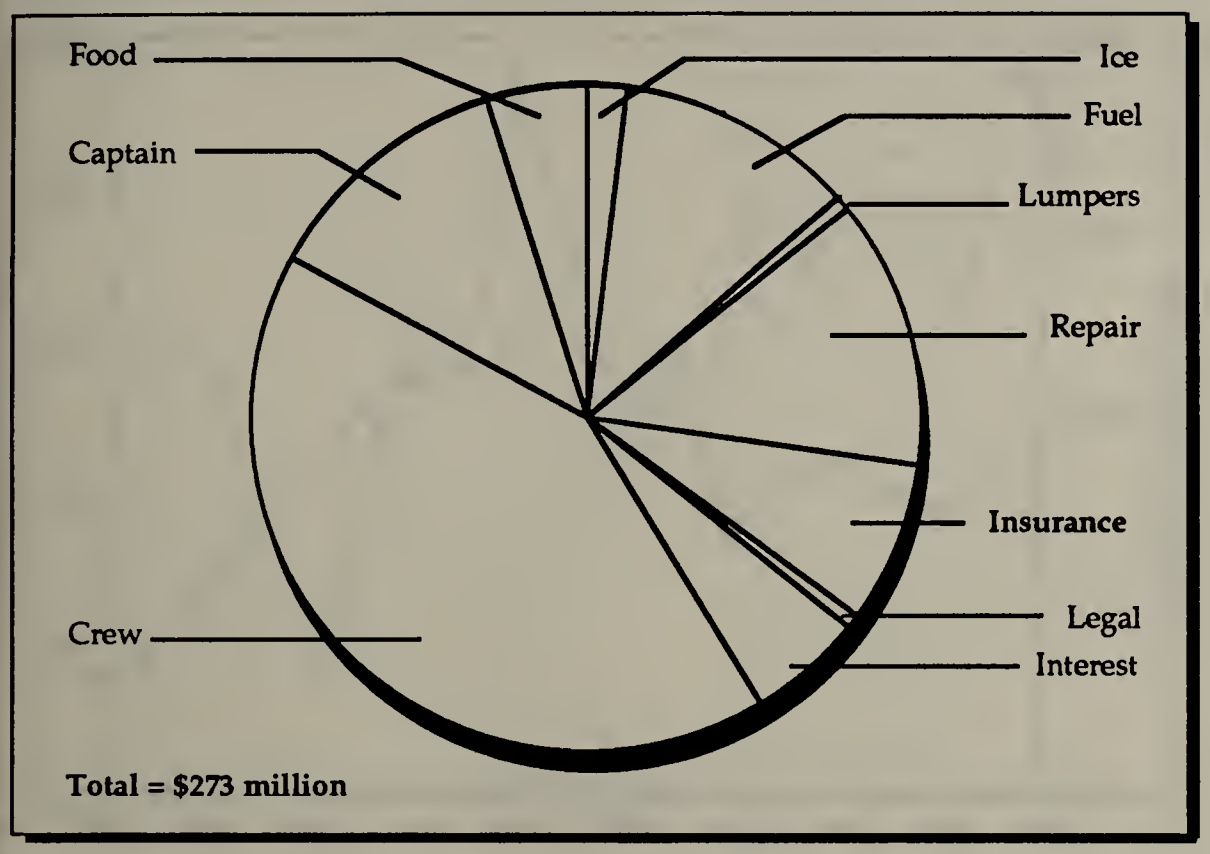


Figure 13. Total Payments from Commercial Fishing (NMFS) 1986

The value of the catch is paid out mostly to the captain and crew. For 1986, the last year for which data are available, the National Marine Fisheries Service (NMFS) estimates that the average captain made about $45,000 and a full-time crewman earned about $25,000. Total payments to captains and their crews totaled about $150 million. The other costs were mostly paid out to local businesses for supplies and services. The fishing sector paid $35 million for gear and repair, $30 million for fuel, $20 million for insurance, $12 million for food for the crew, and a total of $22 million for interest, ice, and unloading the catch (Figure 13). In 1986, the average scalloper in New Bedford paid about $750,000 into the local community, and the average large fishing vessel in Gloucester and Boston paid about $400,000.

The financial health of the fishing sector, however, is declining. Except for recent increases in sea scallops, landings of all other major commercial species have declined significantly. The total catch is now lower than it was before the 200-mile limit extension in 1976.

Fish Processing, Wholesaling, and Retailing

In 1989, about 50 firms processed fish in Massachusetts. NMFS estimates about 3,500 employees in the state's processing sector, while the Massachusetts Department of Employment and Training (DET) estimates an average monthly employment of 2,400 (Figure 14). NMFS includes anyone who worked at any time during the year, while DET averages monthly employment. DET reports a total payroll of about $65 million.

Almost all fish processing firms are located in the major ports of Gloucester, Boston, and New Bedford; they process either fresh fish or frozen fish, but rarely both (Figure 15).

Except for Boston firms which buy fish landed in Portland and Gloucester, fresh fish processors fillet and pack fish landed in or near the port where they are located. Processed scallops, fresh fillets, and other fresh fish, are sold to supermarkets, fish markets, and restaurants. Most fresh fish processing plants are small, with 25 to 100 fish cutters, packers, and other employees. In 1989, total employment for fresh fish processing firms was about 1,200 people.

Frozen fish processors import frozen groundfish blocks from Canada and elsewhere to produce portions, entrees, and dinners. Their products are sold in supermarkets and restaurants. There are only a few of these firms, but they are much larger than the fresh fish processing firms, with 250 to 1,000 employees. In 1989, total employment for frozen fish processing firms was about 2,400. A large proportion of the fish used in McDonald's "fillet-of-fish" sandwiches is produced by Gorton's in Gloucester, one of the oldest fish processing plants in the country.

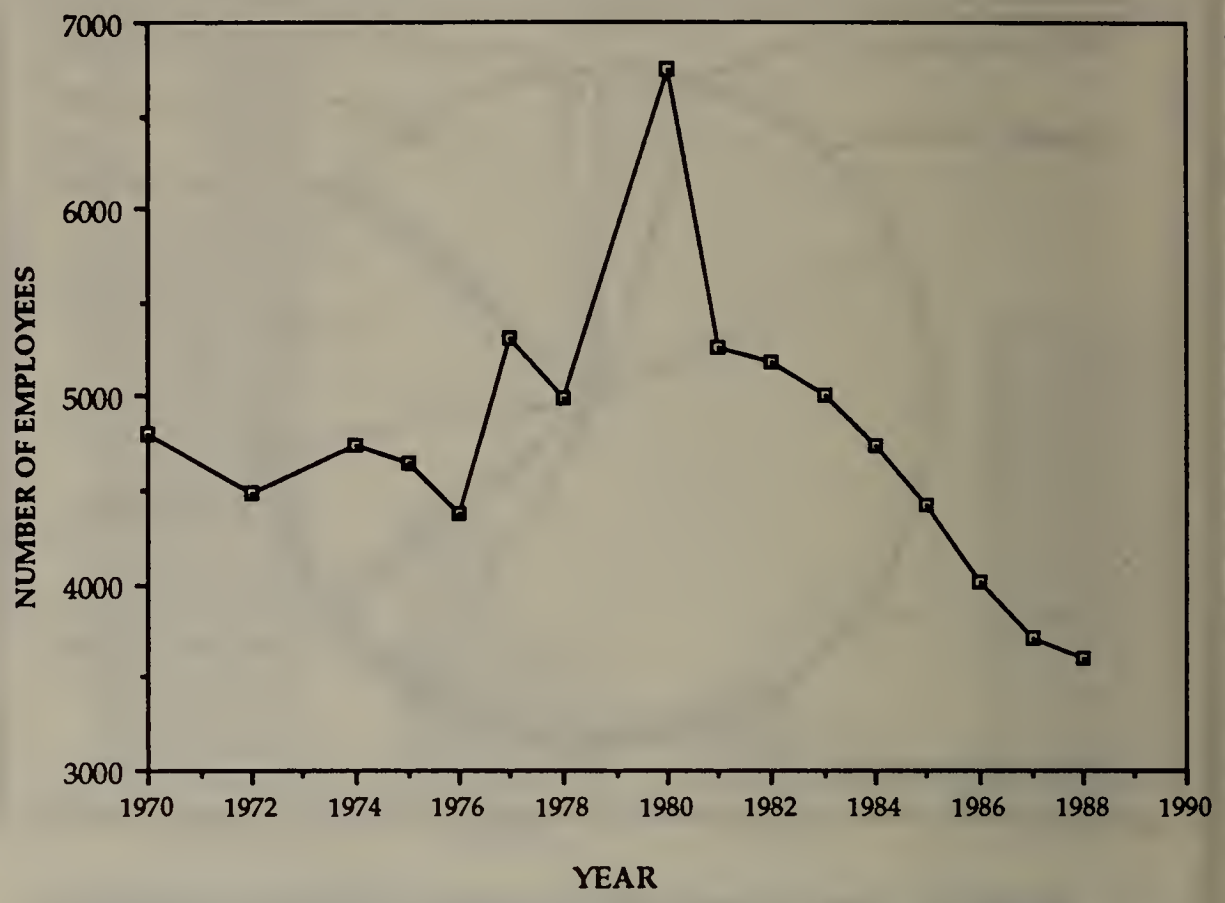


Figure 14. Fish Processing Employment in MA (Fisheries of the U.S.)

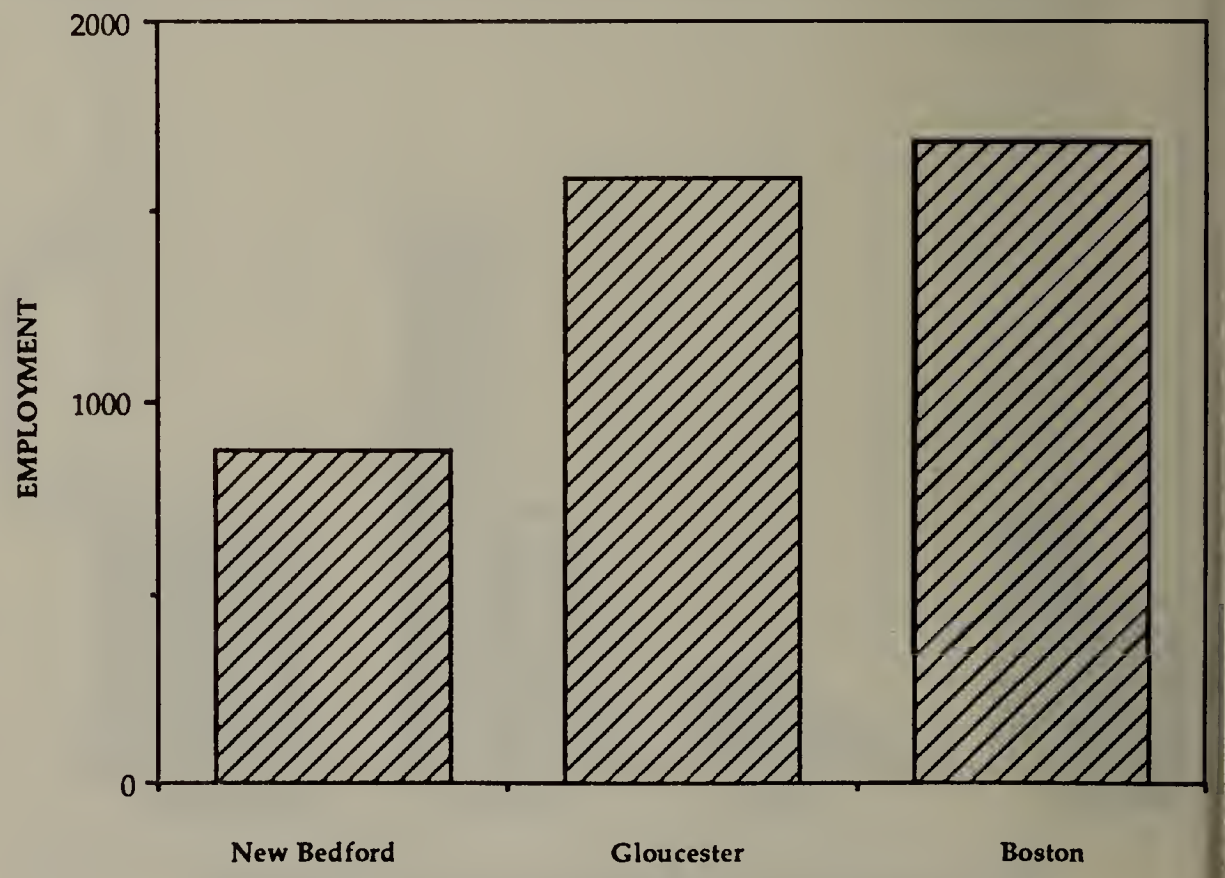


Figure 15. Fish Processing Employment by Port 1989
(MA Directory of Manufacturers)

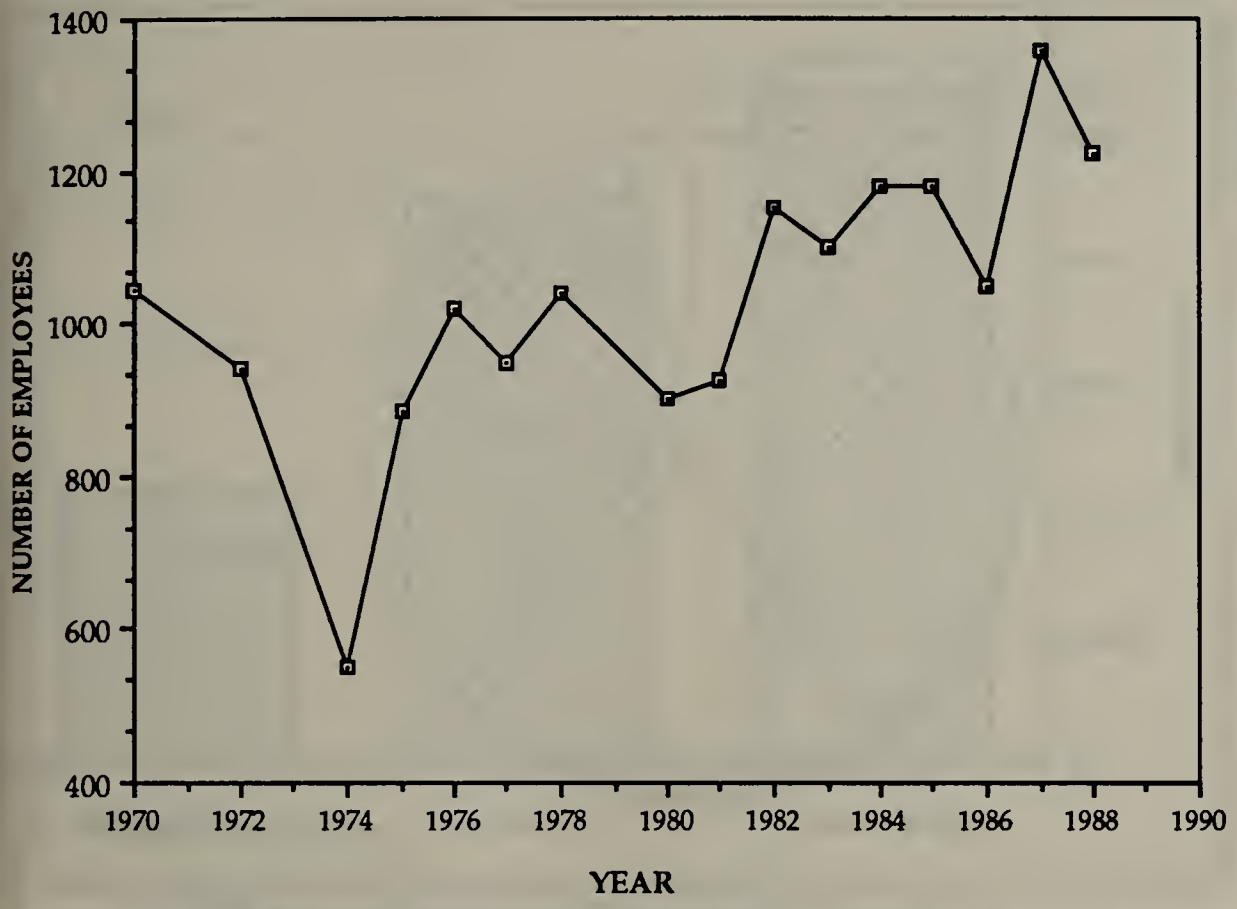


Figure 16. Fish Wholesale Employment in MA (Fisheries of the U. S.)

Like the fishing sector on which it depends, the fish processing industry is declining in Massachusetts. Following the pattern of landings, processing employment has fallen sharply since 1980. From 1980 to 1988, employment fell by 50 percent in Massachusetts (Figure 14). Employment would have declined even more, however, except for an increase in whole fish imports from Canada. The sharp decline in the catch contributed to the decline in fresh fish processing, but the shift to less labor intensive methods of production, such as filleting machines, also caused employment to decline.

Fish is consumed at home or eaten in restaurants. While more fish is currently consumed at home, the value of fish eaten in restaurants is higher.

For 1988 NMFS reports employment of 1,200 people in fish wholesaling in Massachusetts, significantly higher than the employment of 900 reported in 1980 (Figure 16). This odd combination of increasing employment in the wholesale market and decreasing processing employment probably reflects increasing fish consumption in the state while the total catch fell.

There are no estimates of retail or seafood restaurant employment in Massachusetts. Employment data do not distinguish between fish and meat markets, nor do the employment data specify type of restaurant. While retail employment is probably quite low, close to wholesale employment or about 1200 people, employment in seafood restaurants is probably quite high. Almost all restaurants on Cape Cod and the Islands, in Gloucester, and in New Bedford serve and most specialize in seafood. In 1989, DET reported that restaurants in these seaside areas employed about 25,000 people, mostly on Cape Cod (Figure 17). Restaurants in Boston and in other parts of the state also serve seafood and, therefore, are involved in this segment of the marine economy, but we cannot claim that all restaurants in Boston serve seafood, and we have no way to distinguish between seafood and other restaurants.

Restaurants in coastal areas cater to and attract tourists. Eating in a seafood restaurant is an important part of any outing to Cape Cod and the surrounding areas. Cape Cod and the Islands have twice as many restaurants as the rest of the state in proportion to population. Stated another way, restaurants employ about 6 percent of the state's work force, while restaurants employ more than 10 percent of the work force on Cape Cod and the Islands.

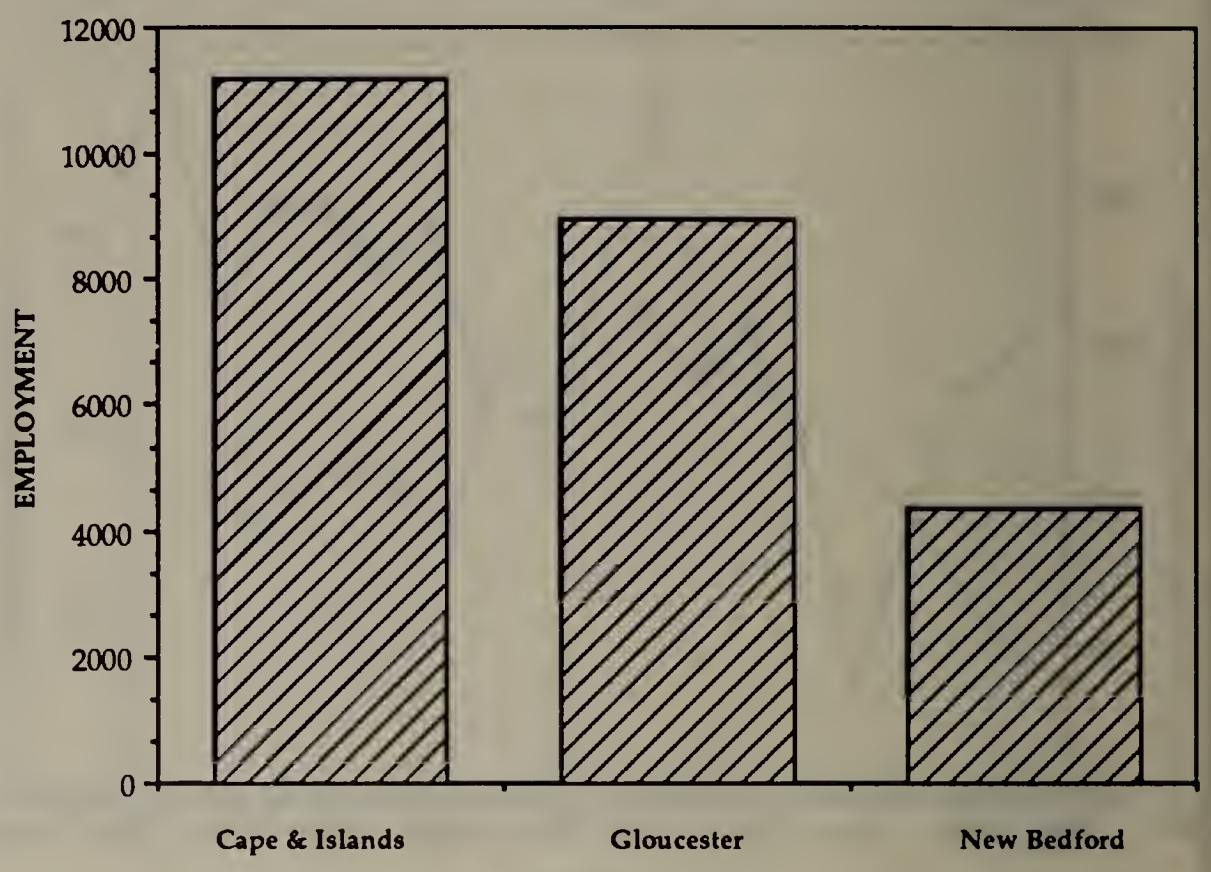


Figure 17. Restaurant Employment by Area 1989

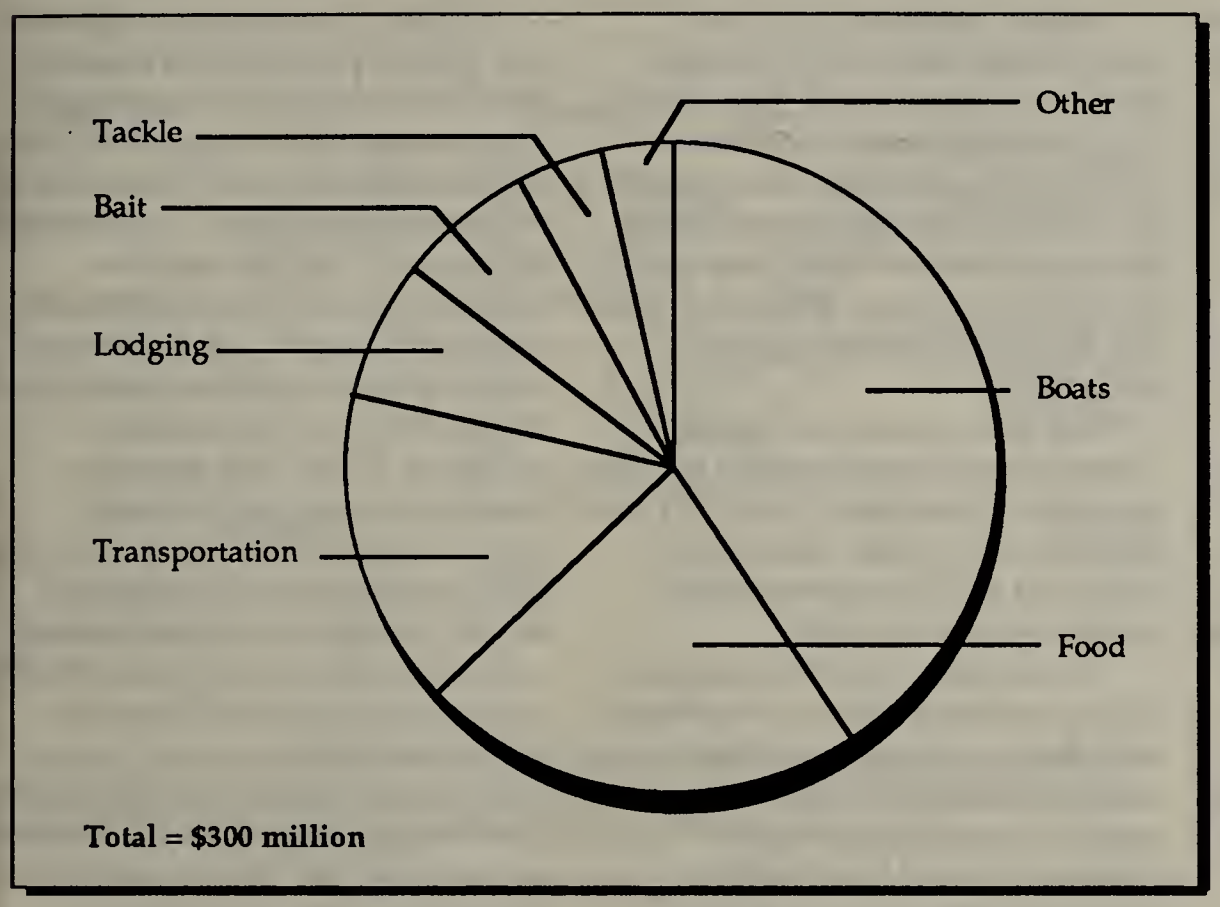


Figure 18. Recreational Fishing Retail Spending in Millions of Dollars 1986 (Sport Fishing Institute)

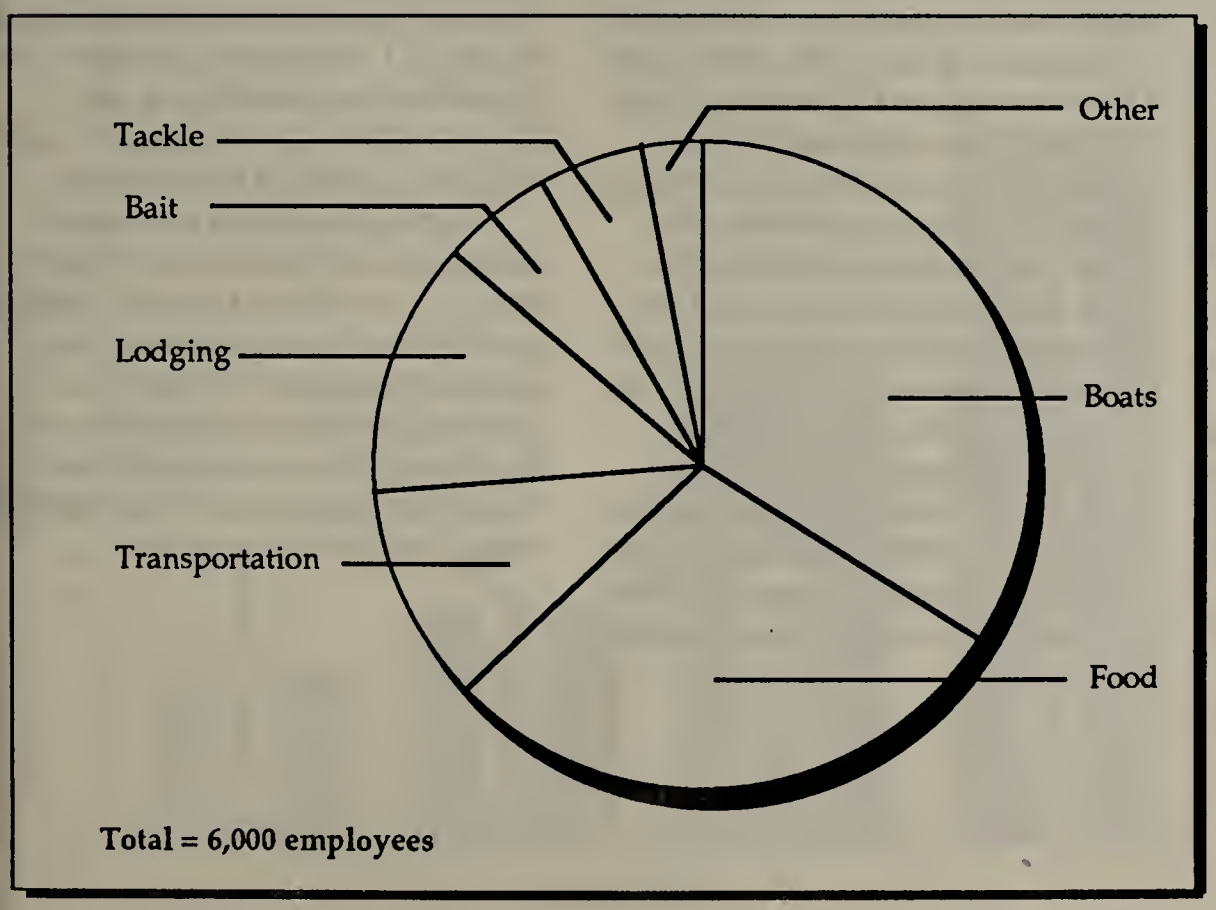


Figure 19. Employment from Recreational Fishing 1986 (Sport Fishing Institute)

Recreational Fishing

Most summaries of the marine economy do not include recreational fishing. However, recreational fishermen use boats, which they either rent or keep at a marina; they repair their boats; they buy gear, bait, and supplies; they eat in restaurants, and those who travel to the seaside often stay in motels.

According to the last NMFS survey in 1986, 700,000 Massachusetts residents made 3 million fishing trips, while another 400,000 out-of-state residents made 1 million trips. Most fishermen were between 25 and 50 years old, with 88 percent men and 12 percent women. They caught about 26 million fish (13 million scup, 4 million flounders, 4 million bluefish, 3 million tautog, and 1 million each of cod, stripped bass, and sea bass). Seventy-five percent were caught within 3 miles of shore from private or rented boats.

Most of the employment connected with recreational fishing is embedded in other categories in the DET data and is difficult to extract. A few statistics, however, are available from this source. In 1989, for example, boat building and repair employed about 1250 and marinas employed about 2100 people. An unknown portion of ship repair employment was for commercial fishing vessels.

The Sport Fishing Institute, a national private non-profit lobbying organization, reported employment of 6,000 in marine recreational fishing in Massachusetts in 1988. These employees earned wages and salaries of $60 million. Most employment was in fishing tackle, boats, food, restaurants, lodging, transportation, and bait (Figure 19). Where they overlap, the Fishing Institute's estimates are quite similar to the DET data.

The Institute reported total retail sales of about $300 million associated with marine recreational fishing. This works out to about $75 per trip, spent mostly for Massachusetts products.

3 Marine Electronics

Marine electronic instrumentation is a rapidly growing new area of high technology. World output was approximately $10 billion in 1986 of which the U.S. share was estimated to be $3 to 5 billion.

In many ways the marine electronics industry provides a skeletal backbone of the marine economy. Marine electronic instruments have become indispensable in undersea defense, offshore oil and gas production, oceanographic research, environmental monitoring, and commercial and recreational fishing. Sonar devices, range and depth finders, fish finders, offshore signal transmitters (both underwater and surface), satellite-based transmission and navigation aids, sea bottom mapping systems, and water quality monitoring instruments are used in a wide range of marine applications. Since these devices can be used in marine environments around the world, the makers of these devices face strong international competition.

Products of the marine electronic industry may be categorized as follows. Sensors, such as acoustic instruments, sonar receivers, finders, sonobuoys, and current meters, pick up electronically transmitted signals emanating from the marine environment. Storage and analysis systems store and analyze these signals. Communication and navigation instruments support marine activities. These include auto-pilots, weather fax machines, fish finders, and electronic instrument systems which use satellite communications for navigation. Advanced military electronics, used in anti-submarine warfare, are combinations of the categories listed above.

Marine electronics services include lease and rental of oceanographic instruments, the execution of oceanographic surveys, underwater photography and inspection, specialized marine data processing, testing of marine electronic instruments, and the analysis of ocean-marine information regarding positioning and navigation.

The gross payroll for the 45 Massachusetts firms involved in these activities as identified by the DET was $632,660,775 in 1989. These firms employed 17,131 workers with average wages of $36,930.

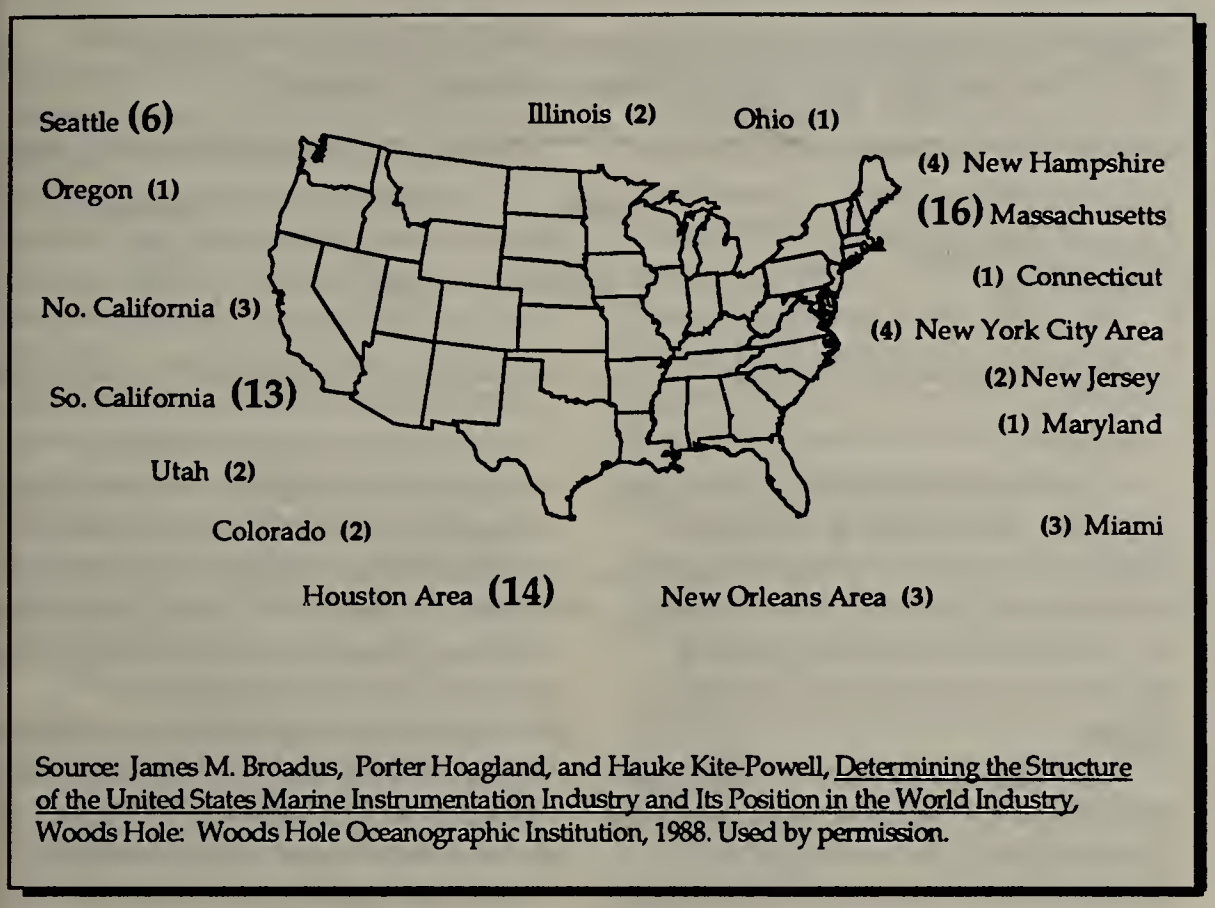
In comparison to other manufacturing industries, the marine electronics industry is clearly a high tech industry. Marine electronics firms employ a higher percentage of professionals and highly skilled workers (scientists and engineers) than other manufacturing industries. This accounts for the relatively high wages in these firms. Research and development (R&D) expenditures are higher than in most other industries, 7 to10 percent of sales. For some firms R&D is as high as 15 percent of sales.

One of the components of the broader marine electronics industry is marine scientific instruments. Because of the high levels of scientific and engineering skills required for marine electronics innovation, firms producing these products tend to be clustered in areas with scientific institutions specializing in marine research. This is shown nationally in Figure 20. In 1988 Massachusetts had 16 firms producing marine scientific instruments, the highest concentration in the country.

Figure 21 illustrates the spawning- ground phenomenon whereby new marine electronics instrument firms are spawned as spin-offs from universities and research institutions with marine programs. An example is the case of Neil Brown who worked at the Woods Hole Oceanographic Institution. He left Woods Hole to found a company called Neil Brown, Inc. This firm was later bought by EG&G and currently manufactures acoustic devices, current measurement equipment, and CDT (simultaneous conductivity/density/temperature measurement) acquisition systems. It has 60 employees and sales between $5 and 10 million annually.

Using a somewhat more comprehensive definition of marine electronics than used by DET, it is possible to identify 56 firms specializing in marine electronics and instrumentation for 1990. Within the Commonwealth of Massachusetts, the greatest concentration of marine electronic firms is in southeastern Massachusetts (Figure 21). Forty-five percent of the 56 marine electronics firms are located within a small radius (a forty-five minute ride) of Woods Hole.

Marine electronics instrument firms spun off from research institutions or universities typically begin as two- or three- person operations in someone's garage. Most grow to achieve sales below $10 million, and they typically serve scientific and research institutions and the offshore energy exploration business.



Source: James M. Broadus, Porter Hoagland, and Hauke Kite-Powell, Determining the Structure of the United States Marine Instrumentation Industry and Its Position in the World Industry, Woods Hole: Woods Hole Oceanographic Institution, 1988. Used by permission.

Figure 20. Geographic Distribution of Marine Scientific Instrumentation Firms in the U.S. 1988

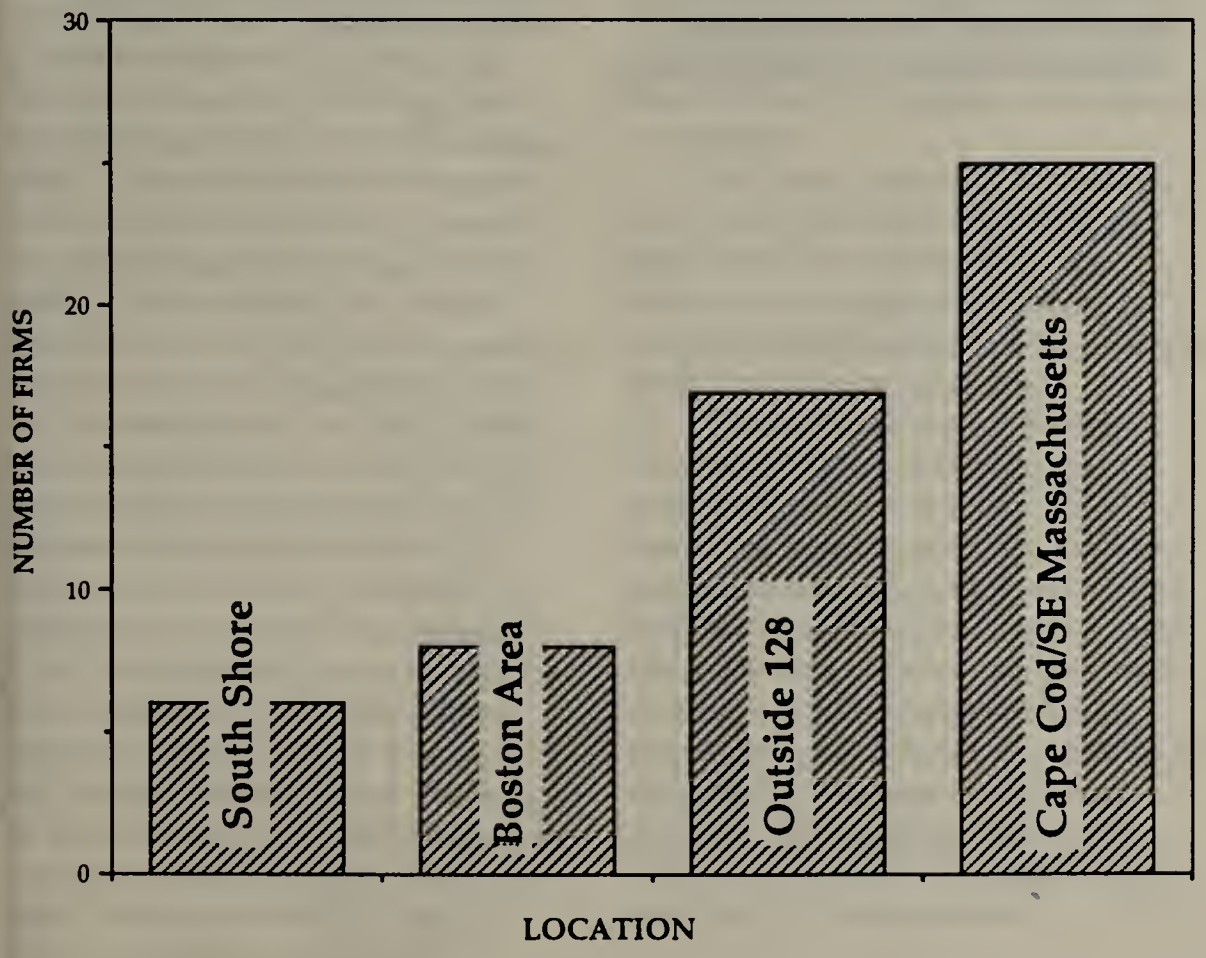


Figure 21. Distribution of Marine Electronics Firms in Massachusetts, 1990 (Source: Same as Figure 20)

Some of the firms in marine electronics produce defense-related products. In 1988 firms in the defense industry in Massachusetts received military contracts worth $7.2 billion of which $2.3 billion was for research and development. An undetermined amount of the R&D work is marine-related. Of the marine-related portion, anti-submarine warfare research accounts for the largest share. In 1986, for example, Sippican attributed 80 percent of its sales to anti-submarine warfare research.

As in the rest of marine electronics, the defense industry employs many highly trained scientists and engineers. Some 60 percent of the defense industry workers attended college as compared to just over 40 percent of workers in other manufacturing firms in Massachusetts.

The marine electronics industry is growing rapidly both in total sales and in the number of firms. It depends heavily on new R&D efforts and the supply of university-trained personnel. At the same time it faces competition with firms around the world to supply oceanographic equipment essential to understanding and preserving the marine environment as well as using it for commercial, scientific, and medical purposes.

4 Marine Environmental Services

There are many services offered in connection with the study, preservation, and improvement of the coastal and marine environments. All of them entail the use of very sophisticated monitoring devices which measure the quality of the marine environment. Some firms specialize in cleanup of oil spills and other pollutants such as PCBs. Others monitor construction sites and other sensitive locations. Much of the demand for these services derives from federal and state environmental regulations. The sales of a sample of four firms engaged in marine environmental services over the last six years increased by about 90 percent, while their employment went up by more than 50 percent (Table 7).

Table 7. Employment and Sales in a Sample of Marine Environmental Coastal Service Firms (4 Firms)

	1983	1989	% Growth
Sales ($millions)	14	26.7	+90
Employees	133	201.0	+51

Environmental services also require personnel with advanced training in science and engineering. For example, in 1983 nearly a quarter of the 133 employees in these firms held Ph.D.s and 66 percent had earned at least a bachelors degree.

Activities of two firms will illustrate the national and world-wide scope of the environmental services industry of Massachusetts. The first firm, Associates of Cape Cod, has used marine biotechnology to create a new medical substance, Limulus Amebocyte Lysate or LAL. This is a diagnostic reagent which can detect minute amounts of bacterial toxins in humans and animals. It was discovered in research with horseshoe crabs. LAL is in demand nationally and around the world for a wide variety of applications. In 1990 Associates of Cape Cod employed 49 scientists and technicians and had sales between $5 and $10 million.

Another firm located in southeastern Massachusetts, Battelle Ocean Sciences, is under contract to assist with the cleanup of the Exxon Valdez oil spill in Alaska. Batelle will monitor the marine environment in the area of the spill for at least another six months after the cleanup. It has been engaged elsewhere to monitor the marine environment at coastal construction sites.

5 Marine Research and Education

Massachusetts is home to many institutions that engage in marine research and education. There are private sector institutions as well as publicly supported institutions funded by the federal or state governments. Nearly all the marine research and education institutions involve effective partnerships among the private sector, the federal government, and state government. The collaboration involved in these institutions is a source of their strength and vitality. Collectively they have over $130 million in annual expenditures.

The village of Woods Hole, part of the town of Falmouth, is the center of marine research in Massachusetts.

The Woods Hole Oceanographic Institution is the most comprehensive and largest private ocean science research and teaching institution in the United States. In addition to a Marine Policy Center and a Coastal Research Center, the Oceanographic maintains five departments: Applied Ocean Physics and Engineering, Biology, Chemistry, Geology and Geophysics, and Physical Oceanography. It runs an education program which features a Joint Program with the Massachusetts Institute of Technology (MIT) offering Ph.Ds and Master of Science degrees in oceanography and ocean engineering. Both the Oceanographic and MIT are Sea Grant institutions, part of a national effort to bring all available resources to the aid of national policies designed to understand, preserve, and optimally use our marine resources. The Oceanographic has achieved an outstanding level of international scientific recognition for its pioneering work in ocean science. Its budget of approximately $77 million annually -- much of which is spent within the state -- makes it a major locus of marine research and education.

The Marine Biological Laboratory (MBL), also located in Woods Hole, was founded in 1888 and is one of the oldest marine science laboratories in the country. Since its inception, 35 Nobel Prize winners have been associated with it. MBL houses one of the largest library collections of biomedical and marine biological publications in the world. MBL has a permanent staff of 200. During the summer months, the MBL hosts as many as 800 scientists and students who undertake research and attend intensive summer courses. While the MBL does not maintain its own undergraduate degree program, the Boston University Marine Program (BUMP) is headquartered at the MBL. BUMP has a staff of six in Woods Hole and provides instruction to 50 undergraduates and 20 graduate students.

Although the Woods Hole Oceanographic Institution (WHOI) and the MBL share many facilities and an excellent working relationship, they are separate institutions with their own staffs, budgets, and sources of funding.

The Tufts University School of Veterinary Medicine maintains a Marine Laboratory at MBL. Its principal investigator carries on an active research program with doctoral and post-doctoral students.

The National Marine Fisheries Service (NMFS) is a federal agency whose charge is to monitor marine resources and to ensure their continued existence and optimal utilization. NMFS studies the size of fish populations, the size of fishermen's catches and the effects of these catches on future fish populations. In addition to this, NMFS maintains a regional office in Gloucester with a testing laboratory, and the Northeast Fisheries Center in Woods Hole.

A branch office of the U.S. Geological Survey (USGS) is also located in Woods Hole. Approximately 80 earth scientists conduct multi-disciplinary research on the submerged continental margins of the east coast of the United States.

Some marine research activity is not centered in Woods Hole. Approximately 81 MIT faculty and researchers are involved in marine research and education, especially from the departments of Biology, the Earth Atmospheric and Planetary Sciences Department, Ocean Engineering, and the Civil, Chemical, Mechanical and Electrical Engineering Departments. MIT's expenditures on marine-related science and engineering are approximately $7 million per year, not including MIT Sea Grant allocations. The New England Fisheries Management Council, located in Saugus, was created as one of 8 area fishery management councils by the 1976 Fishery Management and Conservation Act. Currently, the New England council has a staff of 10, whose annual payroll was $0.5 million in 1990.

In Amherst, Boston, and Dartmouth public universities of the Commonwealth have significant programs in marine-related science and education. The University of Massachusetts at Amherst maintains five marine-related research and teaching programs. These include the Environmental Institute, the Massachusetts Pesticide Analysis Laboratory, an Environmental Engineering Program, Food Science Program with its associated Marine Station, and a Department of Forestry and Wildlife Management. Together these programs employ about 58 individuals with expenditures of about $3 million a year. Each of these programs addresses a separate and vital part of the marine environment.

The University of Massachusetts at Boston is rapidly expanding its marine science programs. In 1988 it established the Urban Harbors Institute whose purpose is to study the ecological and economic problems of urban harbors throughout the United States. Currently the Institute has a $750,000 research grant to study urban harbor transportation systems throughout the country. In addition, U. Mass-Boston has an Environmental Sciences program designed to undertake teaching and research focused on coastal physical oceanography, the chemistry of aquatic systems, environmental microbiology, ocean and coastal law, marine economics and policy, as well as aquatic physiology/ toxicology.

Southeastern Massachusetts University (SMU) in Dartmouth maintains several programs which focus directly on the study and utilization of marine resources, including the multiple aspects of physical, biological, and chemical oceanography. These include at least 37 faculty members (approximately 14 in Biology, 9 in Chemistry and 14 in Electrical Engineering) who specialize in aspects of oceanography and underwater systems engineering. The Biology Department alone offers 11 different courses on the multiple facets of the ocean and marine environments.

Recently SMU was made the headquarters of the Northeast Regional Aquaculture Center. It is one of five such centers established by the United States Congress. With an annual budget of $700,000 the Center sponsors cooperative regional research and extension projects in support of the aquaculture industry in the northeastern United States. In addition to instruction, SMU faculty engage in marine research, much of which is supported by outside agencies such as the National Science Foundation. Several members of the Electrical and Computer Engineering and Chemistry departments are consulted regularly by the Naval Underwater Systems Center Laboratory in Portsmouth, Rhode Island. In recent years, they have worked on the development of a marine navigation receiver utilizing the evolving Global Positioning System. Another project concerns the development of a high-data-rate underwater acoustic telemetry link designed to operate in shallow waters. These projects emphasize marine navigation, underwater communication, and signal processing.

In the spring of 1989, a Center for Marine Science and Technology was established at SMU. The purpose of the Center is to promote research in marine sciences. Plans are now underway to a construct a $10 million Coastal Zone Resources Laboratory at Milliken Battery in New Bedford. The purpose of this laboratory is teaching (both graduate and undergraduate) and research focused on living marine resources, coastal environmental quality, and underwater communications and instrumentation. Once constructed, this facility is expected to generate $3 million in research funding each year. It will operate under the aegis of SMU's Center for Marine Science and Technology (CMasT).

The Massachusetts Maritime Academy located in Buzzards Bay is a public four-year college whose curriculum is highly focused on professional marine training. It has 581 full time and part time students, an annual budget of approximately $7 million and 161 employees. It graduates 125 cadets each year, 60 percent of whom join the merchant marine. Three basic undergraduate degrees are offered: a Bachelor of Science in Marine transportation, a Bachelor of Science in Marine Engineering, and a Bachelor of Science in Facilities and Plant Engineering. These include preparation for a U.S. Coast Guard-administered license as Third Mate and Third Assistant Engineer. Courses in Business Management, Mechanical Engineering and Marine Fisheries are also offered.

Table 8 Education and Research in the Marine Sciences in Massachusetts

	Millions of Dollars*	Staff/Employees
Woods Hole Oceanographic Institution	77.0	900
Marine Biological Laboratory	16.0	200
National Marine Fisheries Service	13.4	187
US Geological Survey	6.1	95
N.E. Fisheries Management Council	0.5	10
Mass. Maritime Academy	7.0	161
MIT	7.2	81
Univ. Mass/Amherst	3.1	58
Southeastern Massachusetts University	1.9	31
Boston University Marine Program	1.1	5
Univ. Mass/Boston	1.1	17
Tufts University Veterinary School	0.3	5
Total	$134.7	1750

*Allocations solely for marine research and education

Table 8 summarizes the resources of these institutions devoted to education and research in the marine sciences. These institutions employ 1725 people and provide $132.5 million annually in payroll. (Other Massachusetts institutions have marine science programs, i.e., Harvard, Tufts, and Northeastern Universities, Boston College, and others.)

Marine science education and research are critical to the marine economy of Massachusetts. Marine electronics, environmental and toxicological testing, and the educational institutions themselves require well educated marine scientists and engineers. The institutions have been the source of several successful spin-off firms generating direct applications of marine science and technology and creating new jobs. Finally, an important part of the institutions' activities is to study and preserve the marine resources of Massachusetts for the future.

6 Marine Recreation and Tourism

Marine recreation and tourism follow a long tradition in Massachusetts. Almost everyone from Massachusetts and millions of visitors fondly remember a day at the beach. Salisbury Beach, Horseneck Beach, the Cape Cod National Seashore and the smaller beaches of the North Shore, the South Shore, Cape Cod, Nantucket, and Martha's Vineyard are known far and wide for sparkling seas, high surf, and white sand. In 1989, the state and national beaches of Massachusetts reported almost 10 million visitors. Cape Cod National Seashore accounted for about half of this total. Several million also visited the hundreds of private and town beaches throughout the state.

There are, unfortunately, no recent economic studies specifically devoted to marine tourism and recreation in Massachusetts. For the labor market areas of Cape Cod and the Islands, Gloucester and the North Shore, and New Bedford in 1989, the DET reports employment of 3,513 with a total annual payroll of $44 million in the category for recreation and amusement. Most if not all of this employment is connected to marine activities. This does not include eating out, lodging, sightseeing, and shopping, important categories of recreation and tourist spending.

For the Boston labor market area in 1989, 10,325 people were employed and earned an annual payroll of $120 million in amusement and recreation. Unfortunately, marine recreation and amusement cannot be separated from other forms of recreation. While other forms may not be significant in the seaside areas noted above, in Boston they are substantial. The precise value of marine recreation in the Boston area, therefore, cannot be identified.

The most recent report on travel and tourism in Massachusetts, prepared by the Massachusetts Office of Travel and Tourism estimates that in 1988 domestic tourists spent $1.0 billion on Cape Cod and the Islands, $400 million in Essex County, $200 million in Bristol County, and $150 million in Plymouth County (Figure 22). These estimates include more activities than the DET employment data. If we assume that all of this spending was marine-oriented, marine tourism generated 22,300 jobs with a payroll of about $319 million (Figure 23). The Office of Travel and Tourism also reports that the seaside areas were the fastest growing tourist areas in the state. From 1987 to 1988, tourism grew by an average of 13 percent on Cape Cod and the Islands and in Bristol, Plymouth, and Essex counties, while tourism grew by less than 9 percent in the rest of the state. The Travel Barometer, a service of the Office for Travel and Tourism, also shows that Cape Cod and Islands drew large numbers of tourists in 1989. The Nantucket and Barnstable airports reported 215,000 passengers and the Martha's Vineyard and Nantucket Ferries reported 2,123,000 passengers.

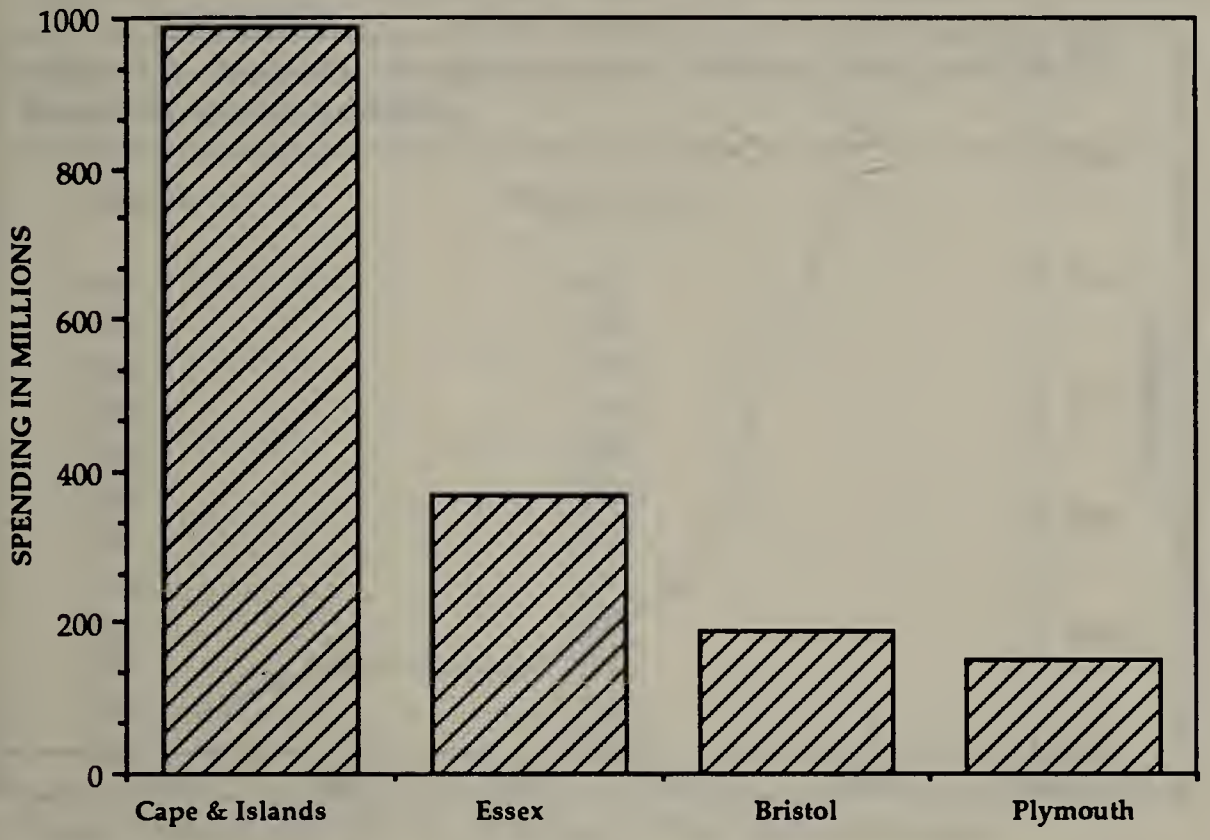


Figure 22. Domestic Tourist Spending by County in 1988 (MA Office of Tourism)

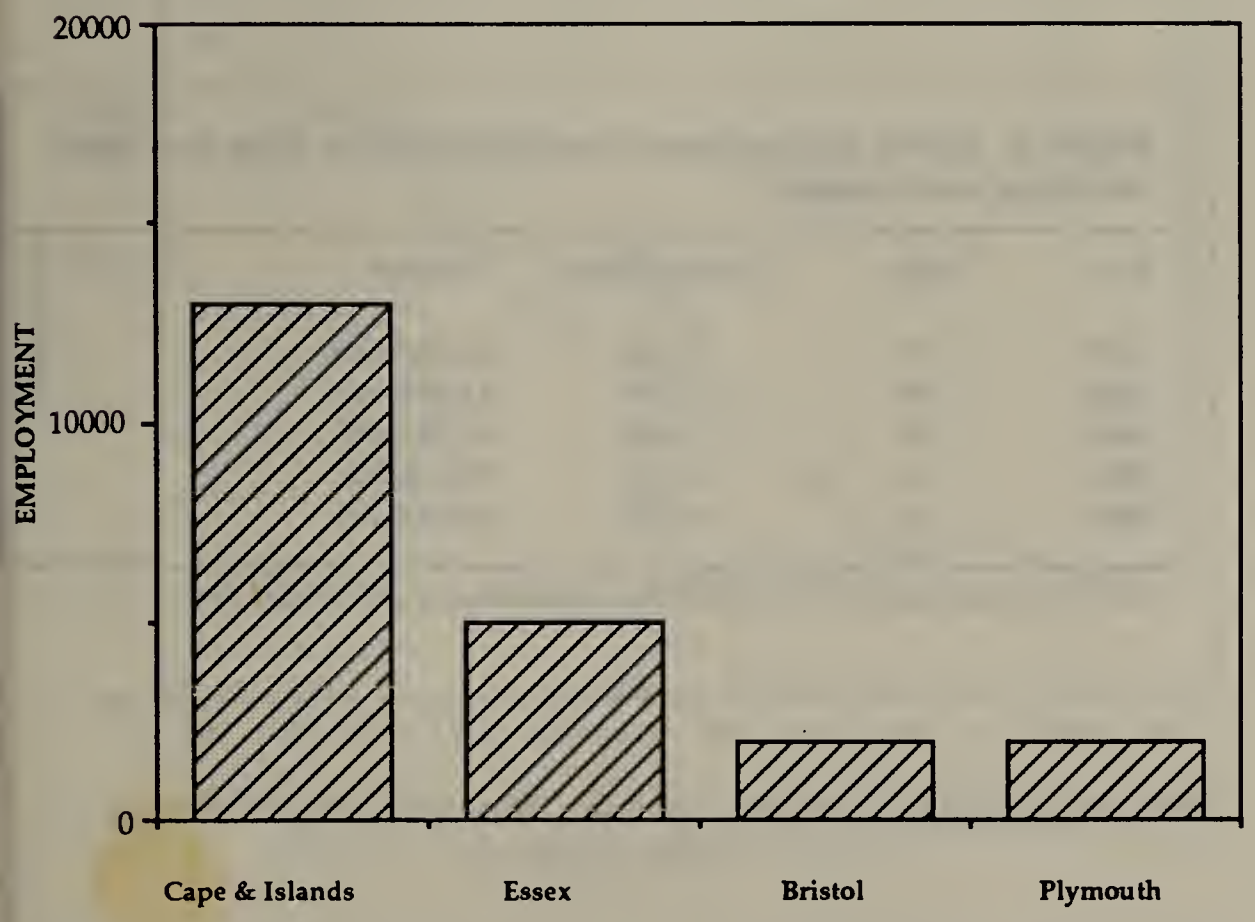


Figure 23. Employment from Domestic Tourist Spending by County in 1988 (MA Office of Tourism)

The Office of Travel and Tourism estimates that tourists spent $5 billion in Boston and surrounding areas in 1988, generating 68,000 jobs with an annual payroll over $1 billion. Unfortunately, as in other sections of this report, we are forced to exclude tourist spending in Boston from estimates for marine tourism and recreation. While tourists come to Boston because of its maritime location, traditions, and attractions (in 1989, the New England Aquarium reported over 1 million visitors), we cannot claim that all tourism in Boston is marine-related, and we have no way to separate marine from non-marine recreation.

As with other sectors of the marine economy, the current recession has taken its toll on tourism and recreation. The Massachusetts Travel Barometer reports that during the spring and summer of 1989 attendance at the state and national beaches was down 5 percent from 1988. Attendance at museums and attractions fell by 7 percent, and the number of travelers at Logan, Nantucket, and Barnstable airports declined by 9 percent,16 percent, and 8 percent respectively. While this evidence is far from conclusive, it supports the widely held belief that tourist spending follows the business cycle.

7 Boat Building, Repair, and Sales

Ship and boat building and repair has declined consistently from 1986 through 1989, with a loss of over 700 jobs from 1986 to 1988 and a sharp drop of almost another 500 jobs from 1988 to 1989. The number of firms and total payroll have also declined significantly. Furthermore, the recent recession appears to have hit the industry hard and early, with a drop in employment of nearly one-third during 1989.

The declines in units, employment, and payroll in ship and boat building and repair are shown in Figure 24 and Table 9.

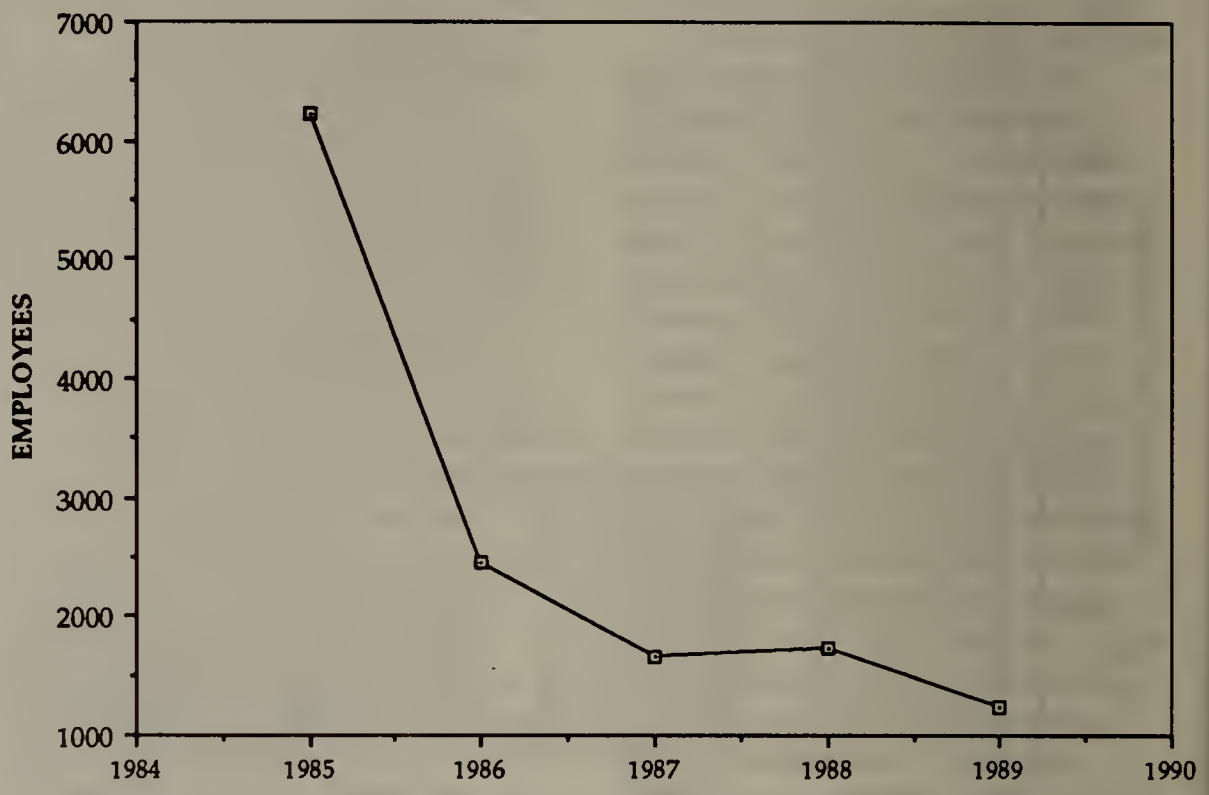


Figure 24. Employment in Ship and Boat Building and Repair, 1985-1989 (Mass. Dept. of Employment and Training)

Table 9. Units, Employment, and Payroll in Ship and Boat Building and Repair

Year	Units	Employment	Payroll
1989	51	1,235	$32,769,844
1988	58	1,729	41,859,440
1987	59	1,665	41,503,407
1986	64	2,461	70,103,761
1985	71	6,225	153,101,701

Source: Massachusetts DET, ES202 file, unpublished public-access data

Table 10. Monthly Employment in 1989 in Ship and Boat Building and Repairing

Month	Employment
Jan	1451
Feb	1403
Mar	1384
Apr	1310
May	1245
Jun	1303
Jul	1207
Aug	1145
Sep	1092
Oct	1111
Nov	1077
Dec	1092

Source: Massachusetts DET, ES202 file, unpublished public-access data

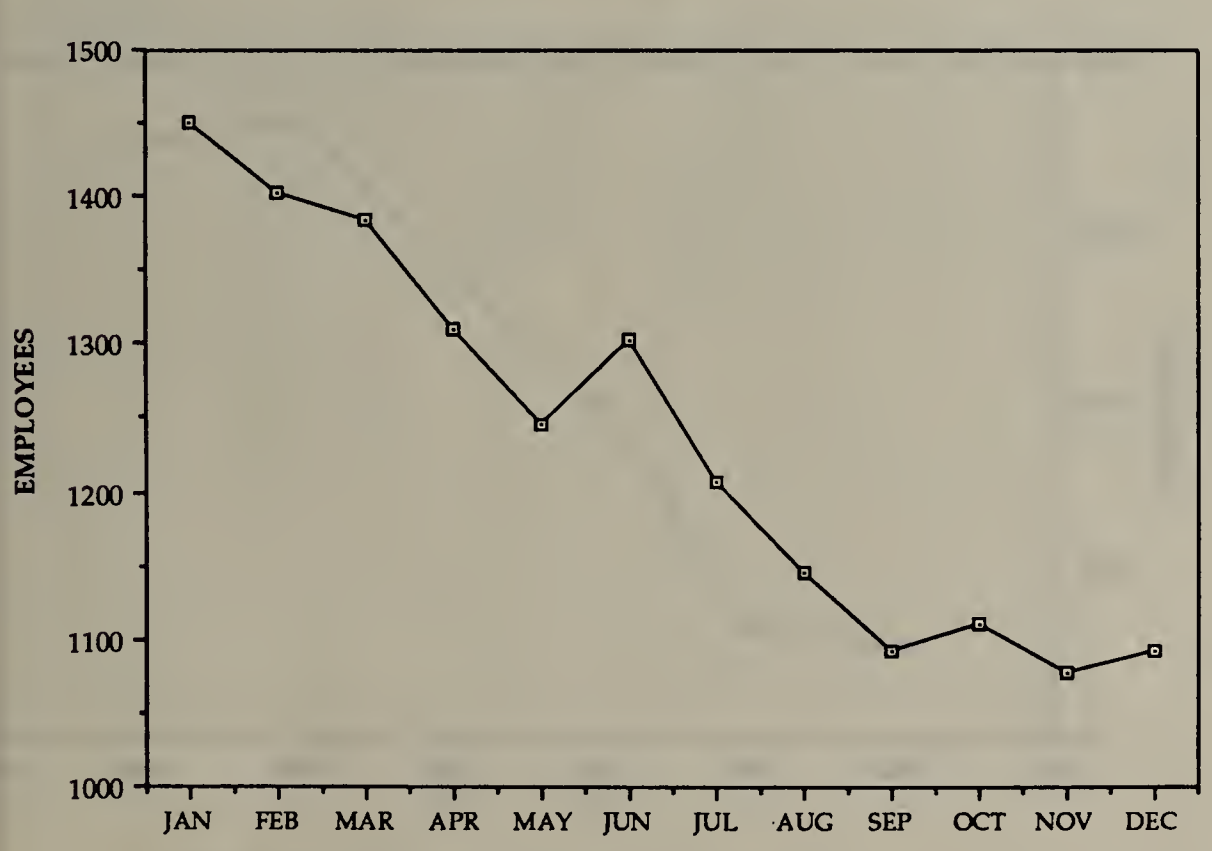


Figure 25. Employment in Ship and Boat Building and Repair, 1985-1989 (Mass. DET)

The pattern of sustained decline is shown even within the most recent year for which data are available, 1989. Table 10 and Figure 25 show the monthly employment for the industry.

The initial decline was due to the closing of the General Dynamics Quincy shipyard in 1985. As Table 9 shows, employment in ship and boat building and repair dropped by more than half from 1985 to 1986. Prior to the Quincy shipyard closing, that plant was the dominant firm in Massachusetts. It was so dominant, in fact, that in years prior to 1985, it represented more than 80 percent of the total employment and payroll in ship and boat building and repairing in Massachusetts. As a result, the Department of Employment and Training did not release data about the total industry to avoid disclosing the operations of this one firm.

Small boat building and repair became the predominant part of the industry after the Quincy shipyard closed. This remaining part of the industry has continued to decline steadily. The Boston Whaler firm, for example, recently moved to Florida.

There are some signs of possible rejuvenation. Newer firms in Massachusetts have taken a lead in applications of composite materials technologies to boat building. Composite technologies involve the development of extremely durable, corrosion-resistant, fiber-reinforced materials. In the past, these materials were limited to fiberglass construction of hulls. Newer developments are exploring structural and propulsion systems and components of boats made of newer generation plastic-fiber composites. Fiberspar, Inc. of Wareham, for example, has been building masts, booms, and other components for sailboards and boats since 1986 and is the exclusive supplier of sailboard masts for the 1992 Olympic Games in Spain. Firms in this sector of the industry continue to explore and experiment with new applications.

Retail boat dealers sell new and used motorboats and other watercraft, marine supplies, and outboard motors. The number of dealers, employment and payroll have increased since 1984 (Table 11 and Figure 26). These increases have occurred while manufacturing output of boats has declined. As is true in other parts of the economy, service activities have expanded while manufacturing has declined.

Table 11. Number of Units, Average Annual Employment, and Total Annual Payroll for Boat Dealers

Year	Units	Employees	Payroll
1989	157	1250	$28,546,322
1988	165	1265	28,870,932
1987	165	1175	25,597,118
1986	145	1095	21,299,404
1985	133	963	16,592,123
1984	136	953	15,784,156

Source: Mass. DET, ES202 file

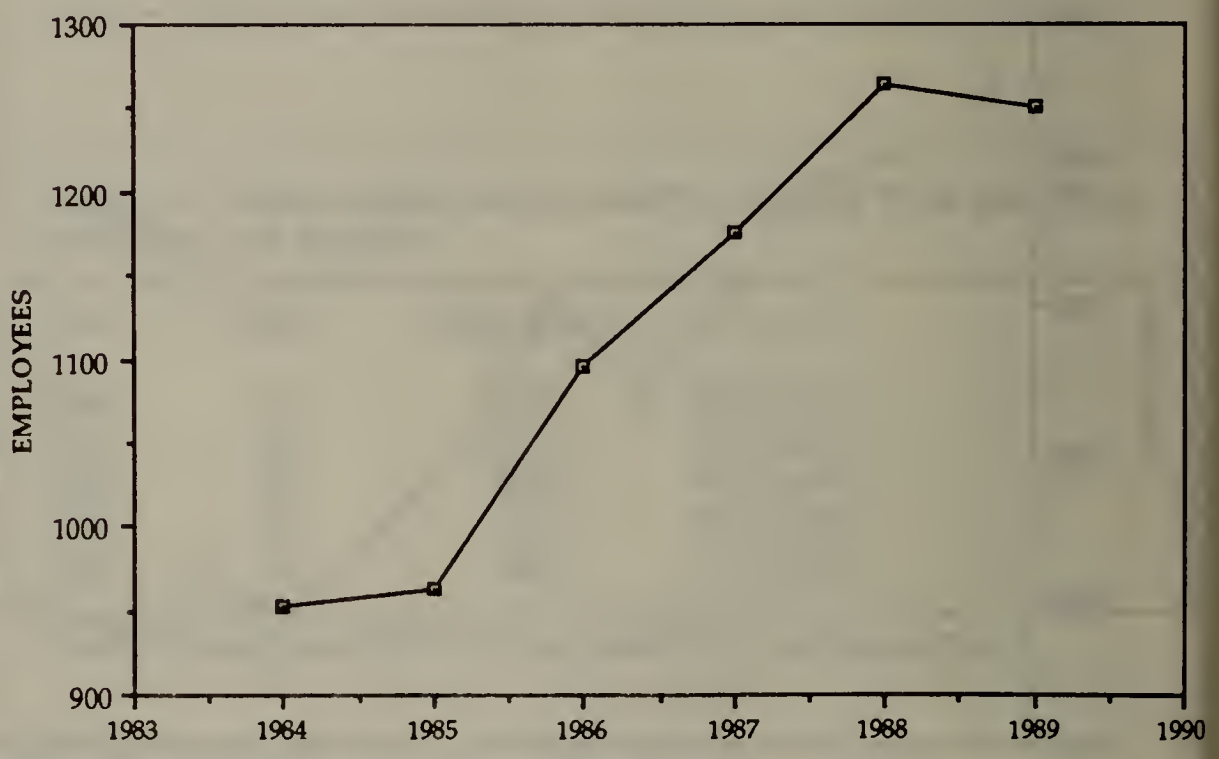


Figure 26. Employment, Retail Boat Dealers, 1984-1989
(Mass Dept. of Employment and Training)

8 Water Transportation

Table 12. Number of Firms (Units), Employment, and Payroll in Water Transportation

Year	Units	Average Annual Employment	Annual Total Payroll
1989	250	2982	$74,578,595
1988	253	3216	74,651,218
1987	283	3643	77,376,074
1986	257	3443	72,218,033
1985	246	3559	67,391,707
1984	233	3303	56,502,787

Source: Mass. DET, ES202 file.

Water transportation includes transportation as well as services in support of water transportation. These support services account for approximately two-thirds of employment and payroll and include marine cargo handling, towing and tugboat services, marinas, and other marine services.

Employment and payroll in water transportation peaked in 1987 at 3,643 and $77,376,074 respectively (Table 12). Both have declined since then with the recession in the Massachusetts economy.

9 Marine Aquaculture

Aquaculture is the cultivation of marine animals or plants for commercial purposes. Although it includes both finfish and shellfish, aquaculture in coastal Massachusetts has so far involved only shellfish: quahogs, softshell clams, oysters, bay scallops, and blue mussels. An adjunct of shellfish aquaculture is the replenishing of local seedbeds where the shellfish stocks have been depleted.

As a form of fish farming, aquaculture is embedded in a larger network of commercial and recreational shellfish harvesting. Aquaculture in Massachusetts is administered by local officials, who lease small plots of coastal land to shellfish aquaculturists who plant and harvest shellfish crops. These are known as grants. This arrangement derives from the Aquaculture Law in Chapter 130 of the Massachusetts General Laws. The net effect of these laws is to place aquaculture under the control of local officials.

Recently, aquaculture grants and the total acreage in these grants have increased by 46 percent and 80 percent respectively (Table 13). However, the number of bushels harvested and the value of this harvest have fallen by about 50 percent and 30 percent respectively (Figure 27 and Table 14). Based on the results of an earlier study of aquaculture commissioned by the Massachusetts Centers of Excellence Corporation, the current amount of aquaculture cultivation would generate employment in a range between 320 and 394 workers.

Table 13. Aquaculture Grants in Massachusetts

	1984	1989	% Change
Grants	82	120	+46%
Acreage	455	821	+80%

Source: Division of Marine Fisheries

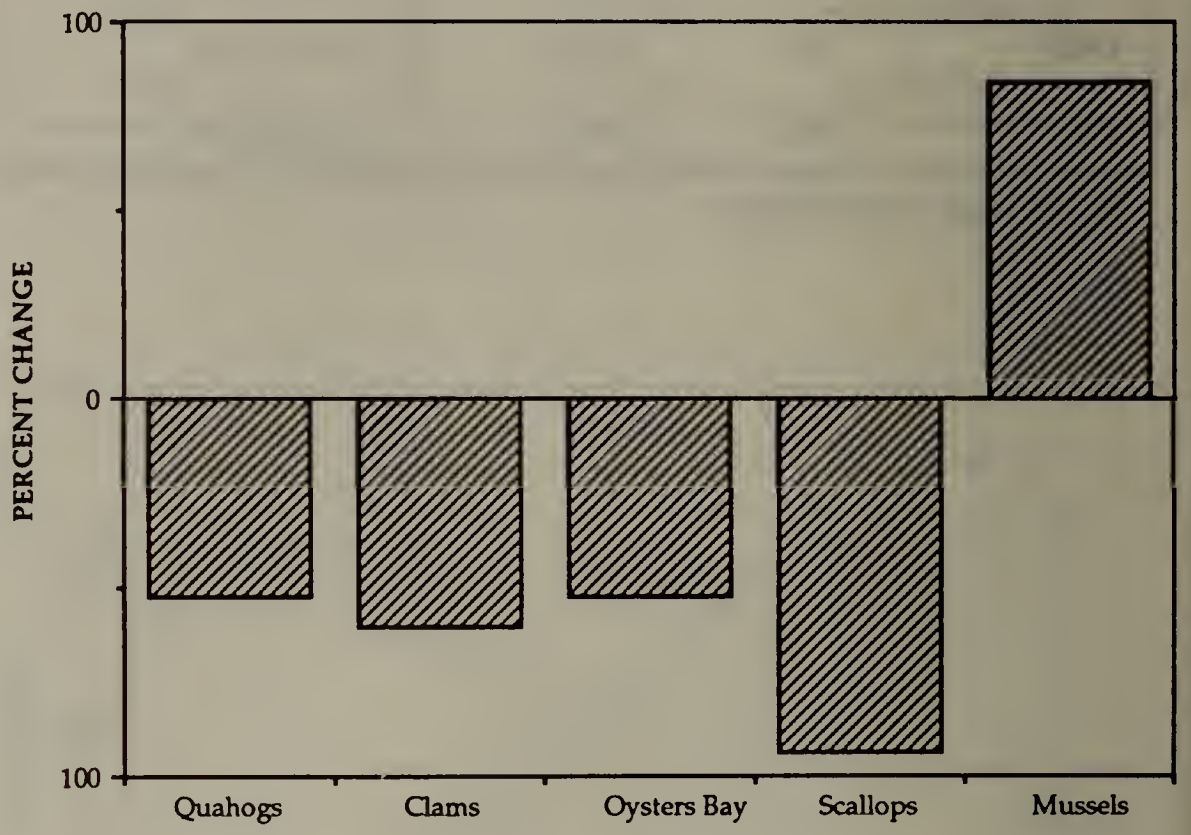


Figure 27. Percent Change in Aquaculture Harvest, 1983-1989 (Div. Marine Fisheries)

Table 14
Reported Shellfish Harvests from Aquaculture Grants

	Sales 1983	Sales 1989	% change	Bu. 1983	Bu. 1989	%Change
Quahogs	$510,166	$291,766	-42	9,826	4,671	-52
Soft Shell Clams	933	688	-26	25	10	-60
Oysters	211,821	207,080	-2	7,759	3,654	-52
Bay Scallops	9,384	702	-92	272	14	-94
Mussels	1,692	3,422	+102	141	260	+84
Totals	$733,996	$503,658	-31	18,023	8,608	-52

Source: Division of Marine Fisheries

A number of factors appear to be involved in the trend of smaller harvests from more acreage and effort. Some aquaculture grants are used only as temporary wet storage grounds for shellfish harvests, and not for the purpose of growing new stock. The portion of wet storage grounds may have increased. Also, shellfish diseases have had a significant impact on aquaculture. In the last two years one large shellfish aquaculture firm lost virtually its whole crop to the MSX shellfish disease. Pollution of coastal waters has also had an impact. As coastal areas are developed, sewage, solid waste, and chemical pollution become increasingly more prevalent in marine environments. A more optimistic consideration concerns the production cycle. The recent increase in aquaculture acreage means that many new grants have been seeded for the first time. Since it takes two and one-half to three years to get a full grown crop, the fruits of expanded aquaculture will probably not be reflected in the official statistics until the data for 1990 and 1991 become available. Future returns may show improved performance.

The reported harvest and its value are significantly less than claims made by the industry, and sales reported by the Massachusetts Division of Marine Fisheries (DMF) may be underestimated. The earlier MCEC study found that the industry's estimate of shellfish aquaculture sales was much higher than the harvest reported by DMF. In 1983, the value of shellfish landings reported by DMF was $733,996 whereas interviews with 17 aquaculture firms reported combined sales of $8.3 million. However, assuming that the ratio of actual sales to those recorded by DMF has remained the same, actual sales in 1989 would only be about $5-6 million, or 30 percent lower than the 1983 sales figures, with an increase in mussel cultivation only.

Taylor Industries is an example of successful aquaculture. Rod Taylor, a biologist at WHOI, developed a system of feeding bay scallop larvae in a laboratory and then transplanted them to inland waters using lantern nets. In 1987, he founded Taylor Industries on 50 acres in Fairhaven. Since then, the firm has expanded to 180 acres in other locations and expects to produce in excess of one million pounds of scallops in the near future.

10 Appendices

A. THE MARINE ECONOMY OF MASSACHUSETTS

1. Tables 1 - 4 in the Overview section present data on coastal areas of Massachusetts. We have defined coastal areas as counties, cities, and towns that have access to the ocean, either directly or through river connections, and whose local economies are substantially marine-oriented. As used in Tables 1 - 4, coastal areas include the following:

Barnstable County: Entire county
Towns of: Barnstable, Bourne, Brewster, Chatham, Dennis, Eastham, Falmouth, Harwich, Mashpee, Orleans, Provincetown, Sandwich, Truro, Wellfleet, Yarmouth
Dukes County: Entire county
Towns of: Chilmark, Edgartown, Gay Head, Gosnold, Oak Bluffs, Tisbury, West Tisbury
Nantucket County: Entire county
Town of Nantucket
Cape Cod & Islands: Counties of Barnstable, Dukes, and Nantucket
Bristol County: Part
Cities and towns of: Dartmouth, Fairhaven, Fall River, New Bedford, Somerset, Swansea, Westport
Essex County: Part
Cities and towns of: Beverly, Essex, Gloucester, Ipswich, Lynn, Manchester, Marblehead, Nahant, Newbury, Newburyport, Rockport, Rowley, Salem, Salisbury, Swampscott
Norfolk County: Part
Cities and towns of: Cohasset, Quincy, Weymouth
Plymouth County: Part
Towns of: Duxbury, Hingham, Hull, Kingston, Marion, Marshfield, Mattapoisett, Plymouth, Scituate, Wareham
Suffolk County: Entire county
Cities and towns of: Boston, Chelsea, Revere, Winthrop
Total Coastal Areas: All of the above counties, cities, and towns
Non-Coastal Areas: All other counties, cities, and towns in Massachusetts
Massachusetts: Entire state total

2. Data for Labor Market Areas (LMAs) are used in several places in this study. LMA employment and payroll data are maintained by the Massachusetts Department of Employment and Training in the ES202 file. The LMAs separately identified and used in this study are:

Salem/Gloucester LMA: Cities and towns of Beverly, Danvers, Essex, Gloucester, Hamilton, Ipswich, Manchester, Marblehead, Middleton, Peabody, Rockport, Rowley, Salem, Swampscott, Topsfield, Wenham (16 cities/towns)

New Bedford LMA: City and towns of Acushnet, Dartmouth, Fairhaven, Freetown, Marion, Mattapoisett, New Bedford, Rochester (8 cities/towns)

Barnstable LMA: Towns of Barnstable, Bourne, Brewster, Chatham, Dennis, Eastham, Falmouth, Harwich, Mashpee, Orleans, Provincetown, Sandwich, Truro, Wareham, Wellfleet, Yarmouth (16 towns)

Dukes County LMA: Towns of Chilmark, Edgartown, Gay Head, Gosnold, Oak Bluffs, Tisbury, West Tisbury (7 towns)

Nantucket LMA: Town of Nantucket

3. Data for the number of employees and total payroll are available for Massachusetts from the Department of Employment and Training (DET), ES202 file. Unfortunately, the categories for which the data are reported are not entirely satisfactory for unique identification of each of the marine industries. Industries are classified in terms of the Standard Industrial Classification (SIC) Code used by the United States Department of Commerce in its various economic censuses and other reports. SIC codes directly relevant for the present study are:

0273, Aquaculture
091, Commercial Fishing
(0912, Finfish; 0913, Shellfish)
209, Miscellaneous Food Preparations and Kindred Products
(2091, Canned and Cured Fish and Seafoods)
(2092, Prepared Fresh or Frozen Fish and Seafoods)
373, Ship and Boat Building and Repairing
(3731, Ship Building and Repairing)
(3732, Boat Building and Repairing)
381, Search, Detection, Navigation, Guidance, Aeronautical, and Nautical Systems, Instruments, and Equipment (same as 3812 which has the same title as 381)
44, Water Transportation
(411, Deep Sea Foreign Transportation of Freight)
(442, Deep Sea Domestic Transportation of Freight)
(443, Freight Transportation on the Great Lakes- St. Lawrence Seaway)
(444, Water Transportation of Freight, Not Elsewhere Classified)
(448, Water Transportation of Passengers)
(449, Services Incidental to Water Transportation)
(4491, Marine Cargo Handling)
(4492, Towing and Tugboat Services)
(4493, Marinas)
(4499, Water Transportation Services, Not Elsewhere Classified)
5146, Fish and Seafoods, Wholesale Distributors
542, Meat and Fish (Seafood) Markets, Including Freezer Provisioners, Retail Markets (same as 5421)
555, Boat Dealers, Retail Markets (same as 5551)
581, Eating and Drinking Places
633, Fire, Marine, and Casualty Insurance
653, Real Estate Agents and Managers
70, Hotels, Rooming Houses, Camps, and Other Lodging Places
7999, Amusement and Recreation Services, Not Elsewhere Classified
842, Arboreta and Botanical or Zoological Gardens (including Aquariums)
8711, Engineering Services (including Designing Ships, Boats, and Machines; Marine Engineering Services)
8731, Commercial Physical and Biological Research
8733, Noncommercial Research Organizations
8734, Testing Laboratories
951, Administration of Environmental Quality Programs

The 2-digit classes are the most comprehensive and are made up of one or more 3-digit classes. These 3-digit components are thus more detailed breakdowns of industries. In the same way, the 4-digit industries are breakdowns of the 3-digit industries. Some of the marine industries are adequately captured by 2-digit industries, for example, 44, Water Transportation. Other marine industries are adequately captured by 3-digit industries, for example, 091, Commercial Fishing. Others are 4-digit industries, for example 2092, Fresh and Frozen Fish Processing. Data for the 4-digit industries are not usually available in the DET files. Thus, for example, wholesale seafood firms, SIC 5146, are not separately identified from other 514 firms; engineering services, SIC 8711, are not separated from other 871 firms. In yet other cases, even a 4-digit industry breakdown may not be sufficiently fine to separate out marine activities from non-marine activities within the same category. For example, 7999, Amusement and Recreational Services,

Not Elsewhere Classified, includes public bathing beaches, pleasure boat rentals, fishing party boat operators, canoe rentals, and houseboat rentals, all of which are marine-oriented. It also includes golf courses, fortune tellers, and karate instruction (and many others) which are not marine-oriented. And it includes lifeguard service which may or may not be marine-oriented. In cases like this, the non-homogeneity of the category makes it difficult or impossible to separate out the marine employment. In general, the approach taken in this study is a conservative one of not counting an industry category if it is not clearly marine-oriented.

4. Data on population and area are taken from the United States Censuses of 1980 and 1990. Data have been provided by the University of Massachusetts's Massachusetts Institute for Social and Economic Research, State Data Center, Amherst and Boston. The final census population counts of Massachusetts cities and towns for 1990 became available in February 1991. Other data from the 1990 census have not been released as this goes to press.

United States Census Bureau estimates of income per capita for cities and towns are used for Tables 3 and 4. When the 1990 census returns for incomes become available, the accuracy of the inter-census estimates may be investigated.

Table 5 is based on the most recent input-output table for the United States, based on the economic censuses (manufactures, services, agriculture) of 1977. The input-output table for the 1982 economic censuses has not been released as this goes to press. Estimation of direct demand by marine industries on other industries is based on the following procedures: the ratio of employee compensation to total industry output for the U.S. is calculated for 1977; this is multiplied by 1989 industry payroll to estimate the total value of industry output in 1989. The ratio of purchases from the major supplying industries to total industry output is calculated for the U.S. for 1977. This ratio is multiplied by estimated total industry output for 1989 to estimate the value of purchases from supplying industries. Because of the changes in the SIC codes from 1977 to 1987, it has not been possible to apply this approach to marine electronics. Until the most recent revision of the SIC codes, that of 1987, marine electronics were not separately identified. Even the present SIC code does not allow a completely unique separation of marine electronics from other related electronic manufacturing.

5. We took a conservative approach to estimating total employment and payroll for the marine economy in order to avoid double counting. For example, we did not include employment from recreational fishing since we assumed that this employment was considered in recreation and tourism. Sources for total employment and payroll in the marine economy as used in Table 6 and Figures 6 &7 are as follows:

Commercial Fishing: NMFS
Fish Processing: DET
Retail and Wholesale Fish Sales: DET
Seafood Restaurants: DET
Recreation and Tourism: Mass. Office of Travel and Tourism
Aquaculture: Employment and payroll from Massachusetts Division of Fisheries and estimated from David Berger, "Aquaculture in Southeastern Massachusetts," in Toby E. Huff, Editor, Studies in the Marine Economy of Southeastern Massachusetts: Aquaculture, Marine Biotechnology, and Commercial Fishing, North Dartmouth: Southeastern Massachusetts Center for Policy Analysis, 1985
Electronics: Employment and payroll from DET, ES202 File, 1989 annual state total
Environment: Employment and payroll estimated from three sources: Mona Racine, "Emerging Biotechnology," in Toby E. Huff, Editor, Studies in the Marine Economy of Southeastern Massachusetts: Aquaculture, Marine Biotechnology, and Commercial Fishing, North Dartmouth: Southeastern Massachusetts Center for Policy Analysis, 1985; Massachusetts Directory of Services 1990-1991, Boston: George Hall, 1990; Massachusetts Directory of Manufacturers, 1990-1991, Boston: George Hall, 1990
Research/Education: Responses by the individual institutions and information provided by Richard Delaney, Director of the Urban Harbors Institute of the University of Massachusetts, Boston
Ship and Boat Building and Repair: DET, ES202 File, 1989 annual, state total for employment and payroll
Water Transportation: DET, ES202 File, 1989 annual, state total, for employment and payroll

B. THE MASSACHUSETTS FISHING INDUSTRY

1. Sources for this section include NMFS, Fisheries of the United States for various years, NMFS Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1986, "The Economic Impact of Sport Fishing in the State of Massachusetts" (Sport Fishing Institute), and the DET ES202 file Data was also supplied to us by: Phil Logan, Chief of Economics Investigation, and Steve Edwards, Economics Assessment Scientist, Northeast Fisheries Center, NMFS, Woods Hole, Stan Wang, Branch Chief, NMFS, Gloucester, Chris Kellogg, Technical Supervisor, The New England Fisheries Management Council, Saugus, Tony Fedler, Director of Economics, Sport Fishing Institute, Washington, DC, and Dennis Main, NMFS Port Agent in New Bedford.

2. In most cases, we used NMFS data for this section. NMFS estimates for employment in fishing are usually higher than DET estimates (NMFS records 3,962, while DET lists 3058) because fishermen working on scallop vessels are considered as self-employed and therefore are not included in the DET survey. Since fishermen often take off a trip (from 7 to 14 days) and are paid at the end of the trip, they may not be included in DET data for that month. NMFS data for processing workers is also higher than DET estimates. Once again this is probably due to DET's method of averaging monthy employment.

3. Data were often in forms that we couldn't use. The number of vessels came from NMFS data on number of vessels registered in the state and vessels landing by port. If a vessel landed in two ports during the year, it was listed twice. In order to correct for this, we estimated the number of vessels by port by multiplying the number of vessels in the state by the share of vessels landing in that port. Likewise, NMFS collected data from different ports for costs paid by vessel. We used a weighted average to estimate the total payments for ice, fuel, etc.

C. MARINE ELECTRONICS

1. The best available study of the national marine electronics industry is James M. Broadus, Porter Hoagland, and Hauke Kite-Powell, Determining the Structure of the United States Marine Instrumentation Industry and Its Position in the World Industry, Woods Hole: Woods Hole Oceanographic Institution, 1988. Figures for total wages and employment in marine electronics instrumentation are from Massachusetts Department of Employment and Training, ES202 file, unpublished public-access data, SIC code 381, for 1989.

2. The description of the "spin-off" and start-up phase of the marine instrumentation firms is taken from Broadus et. al., Ibid., p. 34.

3. The table of marine electronics firms in Massachusetts was compiled from several sources: the appendix of the Broadus, Hoagland, Kite-Powell study, a compilation of marine electronics firms from the Massachusetts Directory of Services, Boston: George Hall,1990; The Massachusetts Directory of Manufacturers,Boston: George Hall, 1990; The Thomas Register 1990; and The Corporate Technology Directory -1989, 4th edition, Wellesley Hills, Ma: Corptech, 1989.

4. Sources for the Defense Industry in Massachusetts include the following reports: Massachusetts Department of Employment and Training (DET), "Adjusting to Changes in Defense Spending: A Report to the Legislature. Executive summary," November 1989; DET, "Defense Industry Profile: Executive Summary," June 1989.

D. MARINE ENVIRONMENTAL SERVICES

1. Sources for this section include: Mona Racine, "Emerging Biotechnology," in Toby E. Huff, Editor, Studies in the Marine Economy of Southeastern Massachusetts: Aquaculture, Marine Biotechnology, and Commercial Fishing, North Dartmouth: Southeastern Massachusetts Center for Policy Analysis, 1985 and Massachusetts Directory of Services 1990-1991, Boston: George Hall, 1990

E. MARINE RESEARCH AND EDUCATION

1. Sources for this section include: Patricia M. Flynn, Facilitating Technological Change. The Human Response Challenge, Cambridge: Ballinger Press,1987, and National Science Board, Science and Engineering Indicators—1987, NSF86-309, Washington , D.C. 1987

2. The estimates of expenditures for those institutions which are totally dedicated to marine research and education (i.e., WHOI, MBL, Mass Maritime, the USGS., and NMFS) were based on their total budgets. For other institutions the expenditure estimates were based on actual expenditures for marine-related personnel and support staff, not total budgets. The information was provided through direct personal contacts with the institutions.

F. MARINE RECREATION AND TOURISM

1. Most of the data for this section was taken from Travel and Tourism in Massachusetts (Massachusetts Office of Travel and Tourism) and the DET ES202 file. Data was also supplied by: Sarah Mann, Director, Massachusetts Office of Travel & Tourism, Malcolm Wilbur, Personnel Director at Cape Cod National Seashore, Charles Dane, Director of Forests and Parks, Massachusetts Office of Parks and Forestry.

G. BOAT BUILDING, REPAIR, AND SALES

1. Data for this were taken the DET, ES202 File. See Appendix A.3 for a discussion of these data.

H. WATER TRANSPORTATION

1. Data for this were taken the DET, ES202 File. See Appendix A.3 for a discussion of these data.

I. MARINE AQUACULTURE

1. The only available study of marine aquaculture firms in Massachusetts known to us is that of David Berger, "Aquaculture in Southeastern Massachusetts," pp. 7-47, in Huff, Op. cit.

2. Berger estimated that among the 17 firms in his study, there were 0 .39 workers per acre for all aquaculture firms, and about 0.48 workers for the active grants; ibid, p. 8. Likewise it was his study of 17 aquaculture firms which arrived at the figure of $8.3 million in sales for 1983 (p. 9). The report on Taylor Ocean Enterprises is by Robert Fitzgerald, "Bay Scallops Return to Buzzards Bay," Seafood Leader (Sept./Oct., 1990), pp. 115-16.